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SKY BRIGHTNESS DURING ECLIPSES: A COMPENDIUM FROM THE LITERATURE

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A collection of sky brightness measurements during solar eclipses is presented with emphasis on photometric measurements. Abstracts and summaries of papers containing data, both visual and photometric, are presented, and the results of the data are summarized.

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Sky Brightness During Eclipses: A Compendium From The Literature

I. GENERAL

The brightness of the sky represents the optical ambient field in which objects are imbedded. Thus detection and identification of targets are dependent on this field. The brightness is a result of both primary and multiply scattered light, with the relative proportions dependent on such factors as solar zenith angle, the part of the sky being looked at, and the amount of dust in the atmosphere. The contributions of primary and multiply scattered light have been studied from a theoretical standpoint. From an experimental standpoint it is possible to obtain some information from such special cases as twilights or eclipses, though here the geometry makes interpretation difficult.

The absence of careful, quantitative spectral data of sky brightness during total solar eclipses led us some years ago to such measurements in the visible, primarily with a scanning spectrometer. Measurements were made at the eclipses

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of 20 July 1963, 12 November 1966, and 7 March 1970. The results were reported in a series of papers.[1-6]

A review paper[7] summarizing the best of the photometric data available in the literature was also prepared. It was not possible in that paper, however, to give appropriate coverage or even to list, most of the papers that have appeared in the literature with some information. In Part 1 of the present publication, we present abstracts and summaries of the data in these various papers. We do not, however, evaluate or convert these data to a common base.

Photometric determinations of the sky brightness are of relatively recent date, that is, within the past 100 years. Some information can also be obtained, at least in principle, from sightings of stars and from such other data as the visibility of print at a known distance. In Part 2 we present the data on star sightings, and in Part 3 those other data from which some conclusions on sky brightness can be inferred.

Partial eclipses are of considerably less interest, since we are dealing essentially with attenuated sunlight, and since a total eclipse automatically includes data for the partial phases. Only a few such measurements have therefore been made. These are given in Part 4.

Lunar eclipses have been studied entirely from the point of view of the lunar surface brightness and deductions that can be made about the earth's atmosphere from this. Only one measurement (unpublished) has been made, as far as we are aware, of the sky brightness during a lunar eclipse. This is included as Part 5.

Finally, we may note that the material presented here is similar in nature and format to the collection of Ranyard,[8] though our scope is considerably less than his.

1. Sharp, W.E., Lloyd, J.W.F., and Silverman, S.M. (1966) Zenith skylight intensity and color during the total solar eclipse of 20 July 1963, Appl. Opt. 5:787-792.
2. Dandekar, B.S. (1968) Measurements of the zenith sky brightness and color during the total solar eclipse of 12 November 1966 at Quehua, Bolivia, Appl. Opt. 7:705-710.
3. Lloyd, J.W.F., and Silverman, S.M. (1971) Measurements of the zenith sky intensity and spectral distribution during the solar eclipse of 12 November 1966 at Bage, Brazil and on an aircraft, Appl. Opt. 10:1215-1219.
4. Velasquez, D.A. (1971) Zenith sky brightness and color change during the total solar eclipse of 12 November 1966 at Santa Ines, Peru, Appl. Opt. 10:1211-1214.
5. Dandekar, B.S., and Turtle, J.P. (1971) Daysky brightness and polarization during the total solar eclipse of 7 March 1971, Appl. Opt. 10:1220-1224.
6. Hall, W.N. (1971) Spectral changes in the zenith sky light during total solar eclipses, Appl. Opt. 10:1225-1231.
7. Sharp, W.E., Silverman, S.M., and Lloyd, J.W.F. (1971) A summary of sky brightness measurements during eclipses of the sun, Appl. Opt. 10:1207-1210.
8. Ranyard, A.C. (1879) Observations made during total eclipses, Mem. Roy. Astrophys. Soc. 41.

In Table 1, the type of information available for total solar eclipses are summarized. Data for the eclipses from 346 A.D. through 1415 A.D. are taken from Ginzel.[9]

2. PHOTOMETRIC RESULTS

The conclusions which can be drawn from past literature on the photometric and spectral characteristics of the sky during total solar eclipses were summarized by Sharp et al.[7] They used the data from six eclipses in the period from 1925 through 1963 which were sufficiently precise so that reasonable conclusions could be drawn. We present here the summary statement quoted from their paper:

> Despite the great variety of techniques used in the measurement of sky brightness, it appears that because of color constancy a standard curve can be constructed with reasonable accuracy that will cover the range from first contact to at least 99.8 percent obscuration. Over this range the brightness can be well represented as a linear function of the percent obscuration. Over the remaining range, multiple scattering from outside the umbral region becomes equal in importance to the direct scattering and at totality is largely responsible for the sky brightness. At totality, sky brightness is of the order of 10^{-3} that of the daytime sky, which may be compared with an order of magnitude of 10^{-6} of the daylight sky for the corona or for the full moon, and is equivalent to a twilight level at ground of about 5-5.5° solar depression angle.
>
> Local and geometrical effects may become important in the range from totality to about 99.9 percent solar obscuration. Sky color changes, almost invariably with a shift to the blue. The brightness is dependent on solar elevation angle, as might be expected since the extra-umbral sky illumination should follow a curve similar to that for the normal day sky. Data from one eclipse indicate that the effect of overcast skies is to increase the zenith intensity by acting as a diffusing layer, which tends to even out the illumination of the entire sky. Existing data do not allow for a final statement on the height dependence of the brightness. Some indication of albedo independence is present in past results. This experimental survey also indicates that the intensity is not constant during totality, and it appears likely that geometrical factors may be important here.
>
> Finally, we may note that it would be desirable to interpret these results in terms of a theory that would clearly define these various geometrical and terrain factors. While some approximate theories have been presented that confirm Halley's conclusion that much of the light originates at some distance from the umbra, a definitive theory is not yet available. We therefore have presented the results of this survey as experimental in nature and have not attempted a theoretical evaluation.

The more recent work from this laboratory (op. cit.) does not significantly alter these conclusions. More detail on the color shift between day sky and totality, and on the height dependence of the intensity can be found in these papers. In the present publication, we include data used in the survey paper as well as all other photometric measurements we have been able to find. These are presented without judgement and without conversion to a common base.

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9. Ginzel, F.K. (1883, 1884) Astronomische Untersuchungen uber Finsternisse, Sitzber. Wien. Akad. Wiss. 88:629-755 (1883); 89:491-559 (1884).

Table 1. Eclipse Information Available

Identification Number	Eclipse Date	Location	Coordinates		Type of Information Available		
			Lat	Long	Photo-Metric	Star	Other
-1375 A	3 May 1375 B.C.	Ugarit, Syria	35°37'N	35°47'E		x	
346 A	5 June 346	Campania				x	
418 A	18 July 418	Byzantium				x	
418 B	"					x	
540 A	19 June 540	England				x	
540 B	19 June 540	Trier, France	49°19'N	5°57'E		x	
563 A	2 Oct 563	Clermont, France				x	
693 A	4 Oct 693	Byzantium				x	
693 B	4 Oct 693	Pavia, Italy	45°12'N	9° 9'E		x	
840 A	5 May 840	France				x	
840 B	"	Germany				x	
840 C	"	Belgium - Netherlands				x	
840 D	"	Italy				x	
878 A	29 Oct 878	Iceland				x	
878 B	"	France				x	
878 C	"	Belgium				x	

Table 1 (Contd.). Eclipse Information Available

878 D	29 Oct 878	Germany - Switzerland	x
891 A	7 Aug 891		x
939 A	18 July 939	Italy	x
968 A	21 Dec 968	Byzantium	x
968 B	21 Dec 968		x
990 A	20 Oct 990		x
1033 A	28 June 1033	France	x
1133 A	1 Aug 1133	England	x
1133 B	"	Belgium - Netherlands	x
1133 C	"	Germany	x
1133 D	"	Austria	x
1140 A	20 Mar 1140	England	x
1147 A	25 Oct 1147	Belgium - Netherlands	x
1187 A	3 Sept 1187	Denmark - Sweden	x
1187 B	"	Austria - Poland	x
1187 C	"	Italy	x
1191 A	22 June 1191	England	x
1241 A	6 Oct 1241	Germany	x

Table 1 (Contd.). Eclipse Information Available

1267 A	24 May 1267	Constantinople	41° 2'N	28°59'E	x	
1415 A	6 June 1415	Austria - Poland			x	
1560 A	1560					x
1699 A	13 Sept 1699	Nurenburg	49°27'N	11° 5'E	x	
1706 A	12 May 1706	Geneva, Switzerland	46°13'N	6° 9'E	x	x
1706 B	"	Marseilles, France	43°18'N	5°22'E	x	
1706 C	"				x	
1715 A	22 Apr 1715	Upsala, Sweden	59°55'N	18° 8'E	x	x
1715 B		London, England	51°30'N	0°10'W	x	x
1715 C	"				x	
1724 A	22 May 1724	Amesbury, England	51°10'N	1°47'W	x	
1724 B	"	Paris, France	48°52'N	2°20'E	x	
1778 A	24 June 1778	Ship at sea			x	
1806 A	16 June 1806	Kinderhook, N. Y.	42°22'N	73°36'W	x	x
1806 B	"	Salem, Mass.	42°32'N	70°53'W	x	
1811 A	17 Sept 1811	Burlington, Vermont	44°28'N	73°14'W		x
1832 A	27 July 1832	Great Cayman Island	19°20'N	81°15'W	x	
1834 A	30 Nov 1834	Beaufort, South Carolina	32°26'N	80°40'W	x	

Table 1 (Contd.). Eclipse Information Available

1842 A	8 July 1842	Venice, Italy	45°26'N	12°20'E	x	x
1842 B	"	Perpignan, France	42°42'N	2°54'E	x	
1842 C	"	On the sea shore			x	
1842 D	"	Narbonne, France	43°11'N	3° 0'E	x	
1842 E	"	Montpellier, France	43°36'N	3°53'E	x	
1842 F	"	Digne, France	44° 5'N	6°14'E	x	
1842 G	"	Lodi, Italy	45°19'N	9°30'E	x	x
1842 H	"	Novara, Italy	45°27'N	8°38'E	x	
1843 A	21 Dec 1843	Parratt	11°45'N	$5^h\ 3^m$E	x	x
1851 A	28 July 1851	Bue Island, Norway	61°10'N	4°21'E		x
1851 B	"	Frederiksvaern	55°58'N	12° 2'E		x
1851 C	"	Christiania	59°54'N	10°43'E		x
1851 D	"	Gottenburg, Sweden	57°45'N	12° 0'E		x
1851 E	"	Trollhattan, Sweden	58°17'N	12°20'E		x
1851 F	"	Christianstadt	56° 4'N	14°10'E		x
1851 G	"	Hill near Gottenburg	57°45'N	12° 0'E		x
1858 A	15 Mar 1858	Scotland - England				x
1860 A	18 July 1860	N. W. British America	53°46'N			x

Table 1 (Contd.). Eclipse Information Available

1860 B	18 July 1860	Cape Chudleigh, Labrador				x
1860 C	"	Steilacoom, Washington Territory	47° 3'N	122°37'W		x
1860 D	"	Palmas, Spain	40° 5'N	0° 0'E	x	x
1860 E	"	Rivabellosa, Spain	42°43'N	2°55'W	x	x
1860 F	"	Burgos, Spain	42°21'N	3°41'W		x
1860 G	"	Vitoria, Spain	42°51'N	2°40'W	x	x
1860 H	"	St. Lorenzo Mountain	42°20'N	3° 2'W		x
1860 I	"	Pobes, Spain	42°48'N	2°54'W		x
1860 J	"	Herena	42°47'N	2°53'W		x
1868 A	18 Aug 1868	Beejapoor	16°50'N	75°48'E		x
1868 B	"	Siam			x	x
1868 C	"	Barram Point, Borneo	4°35'N	113°55'E	x	x
1868 D	"	Vumpurthy	16°22'N	78° 5'E		x
1868 E	"	Wha-Tonne	11°42'N	99°48'E		x
1868 F	"	Mantawalu Kiki, Celebes	0°33'S	123° 5'E	x	
1868 G	"				x	
1869 A	7 Aug 1869	Mattoon, Illinois	39°29'N	88°21'W	x	
1869 B	"	Ottumwa, Iowa	41° 2'N	92°26'W		x

Table 1 (Contd.). Eclipse Information Available

1869 C	7 Aug 1869	Des Moines, Iowa	41°35'N	93°35'W	x	x
1869 D	"	Bristol, Tennessee	36°35'N	82°12'W	x	
1869 E	"	Springfield, Illinois	39°49'N	89°39'W	x	
1869 F	"	Payson, Illinois	39°48'N	91°20'W	x	x
1869 G	"	Oakland Station, Kentucky	37°N	86°29'W	x	
1869 H	"				x	x
1869 I	"		36°35'N	82° 9'W	x	
1869 J	"	White Top Mountain, Virginia	36°40'N	81°35'W	x	
1869 K	"	Plover Bay, Siberia	64°20'N	173°15'W	x	x
1870 A	22 Dec 1870	San Antonio	36°37'N	6°11'W	x	x
1870 B	"	Syracuse, Sicily	37° 4'N	15°18'E		x
1870 C	"	Gibraltar	36° 9'N	5°21'W		x
1870 D	"	Jerez	36°44'N	6°10'W		x
1870 E	"	Seville, Spain	37°24'N	5°59'W		x
1870 F	"	Oran, Algeria	35°45'N	0°38'W		x
1870 G	"					x
1871 A	12 Dec 1871	Number VI Island, Australia				x
1875 A	6 Apr 1875	Bangkok, Siam	13°44'N	100°30'E	x	x

Table 1 (Contd.). Eclipse Information Available

1878 A	29 July 1878	Rawlins, Wyoming Territory	41°46'N	107°16'W			x
1878 B	"	Denver, Colorado	39°45'N	105° 0'W		x	x
1880 A	11 Jan 1880	Santa-Lucia				x	x
1882 A	17 May 1882	Sohag, Egypt	26°33'N	31°42'E		x	x
1883 A	6 May 1883	Caroline Island	15° 0'S	150°15'W		x	x
1883 B	"	"	"	"			x
1885 A	9 Sept 1885	Wellington, New Zealand	41°17'S	174°47'E			x
1885 B	"	Nelson, New Zealand	41°18'S	173°17'E			x
1885 C	"	Woodstock, New Zealand				^	
1886 A	28-29 Aug 1886	Carriacou Island	12°15'N	61°30'W			x
1886 B	"	Grenada	12° 5'N	61°45'W	x	x	x
1886 C	"	Hog Island	25° 6'N	77°18'W	x		
1886 D	"	West Indies				x	
1887 A	19 Aug 1887	Steglitz, Germany	52°28'N	13°20'E		x	x
1887 B	"	Goldap, East Prussia	54°19'N	22°19'E			x
1887 C	"	Kleistshohe, Germany					x
1887 D	"	Kolmar, Germany					x
1887 E	"	Nolinsk, Russia	57°38'N	49°52'E			x

Table 1 (Contd.). Eclipse Information Available

1887 F	19 Aug 1887	Tomsk, Russia	56°30'N	85° 5'E		x
1887 G	"	Mount Blaghodat, Russia			x	x
1887 H	"	Chlamostino, Russia				x
1887 I	"	Elpatievo Narishkine			x	
1889 A1	1 Jan 1889	Liegan, California			x	x
1889 B1	"	Sierra Nevadas				x
1889 C1	"	Chico, California	39°46'N	121°50'W		x
1889 A2	22 Dec 1889	Cape Ledo, Africa				x
1893 A	16 Apr 1893	Mina Bronces, Chile				x
1893 B	"	Fundium, Senegal			x	x
1896 A	9 Aug 1896	Orlovski, Russia			x	
1896 B	"	Bodo, Norway	67°18'N	14°26'E	x	
1896 C	"	Aboard ship			x	
1898 A	22 Jan 1898	Viziadrup, India			x	x
1898 B	"	Jeur, India	18°15'N	75°14'E	x	
1898 C	"	Talni, India			x	
1898 D	"	Bombay, India	18°56'N	72°51'E	x	
1900 A	28 May 1900	Ovar, Portugal	40°52'N	8°38'W	x	x

Table 1 (Contd.) Eclipse Information Available

1900 B	28 May 1900	Elche, Spain	38°16'N	0°41'W	x	x
1900 C	"	Juliette, Georgia	33° 7'N	83°45'W	x	x
1900 D	"	Norfolk, Virginia	36°45'N	76°18'W	x	x
1900 E	"	Virginia Beach, Virginia	36°51'N	75°59'W		x
1900 F	"	Reservoir Hill	38°55'N	77°W		x
1900 G	"	Barnesville, Georgia	33° 4'N	84° 9'W	x	x
1900 H	"	Washington, Georgia	33°43'N	82°46'W	x	x
1901 A	18 May 1901	Mauritius	20°S	54°E		x
1901 B	"	Solok, Sumatra	0°45'N	100°42'E	x	x
1905 A	30 Aug 1905	Alcocebre, Spain	40°15'N	0°16'E		x
1905 B	"	Guelma, Algeria	36°29'N	7°25'E	x	
1905 C	"	Alcala de Chisvert, Spain	40°19'N	0°13'E	x	x
1905 D	"	Alhama, Spain	37°51'N	1°25'W		x
1905 E	"	Ship in the Mediterranean			x	
1905 F	"	Burgos, Spain	42°21'N	3°41'W	x	
1905 G	"	Daroca, Spain	41° 7'N	1°25'W		x
1905 H	"	Porta Coeli, Spain	39°52'N	0°28'W	x	
1905 I	"	On ship off Capricorn, Spain	40°12'N	0°17'E	x	x

Table 1 (Contd.). Eclipse Information Available

1908 A	3 Jan 1908	Flint Island	12°48'N	45° 0'E		x	x
1910 A	9 May 1910	Tasmania					x
1911 A	28 Apr 1911					x	x
1911 B	"	On board SS. Tofua, in Pacific				x	
1912 A1	17 Apr 1912		48°49'N	0°21'W	x		
1912 B1	"	St. Germain-en-Laye, France	48°53'N	2° 4'E		x	x
1912 C1	"	Olhomarinho, Portugal	40°52'N	8°38'W		x	
1912 D1	"	Eaubonne, France	49°N	2°17'E		x	x
1912 E1	"						x
1912 F1	"	Paris, France	48°52'N	2°20'E		x	x
1912 G1	"	Balloon near Rethondes, France					x
1912 A2	10 Oct 1912	Passa Quatro, Brazil	22°23'N	44°59'W			x
1914 A	21 Aug 1914	Stromsund, Sweden	63°51'N	15°35'E			x
1914 B	"	Minsk, Russia	53°51'N	27°30'E		x	x
1914 C	"	Hernösand, Sweden	62°37'N	17°55'E		x	
1918 A	8 Jun 1918	Rock Springs, Wyoming	41°35'N	109°13'W	x		
1918 B	"	Lakin, Kansas	37°57'N	101°16'W	x		
1918 C	"	On U. S. S. Dixie off Bona, Algeria	36°55'N	7°47'E		x	

Table 1 (Contd.). Eclipse Information Available

1919 A	28 May 1919	Sobral, Brazil	3°45'S	40°20'W			x
1922 A	21 Sept 1922	Stanthorpe, Queensland	28°37'S	151°52'E		x	
1922 B	"	Wallal, Australia	19°50'S	120°45'E		x	x
1922 C	"	Australia			x		
1922 D	"	Goodiwindi, Queensland			x		
1923 A	10 Sept 1923	Airplane at 16,500 ft.					x
1923 B	"	Airplane at 12,000 ft.				x	
1925 A	24 Jan 1925	New York - Ontario - Connecticut			x		
1925 B	"	Saugerties, New York	42° 5'N	73°56'W		x	
1925 C	"	Guilford, Conn.	41°16'N	72°41'W		x	
1925 D	"	Poughkeepsie, New York	41°43'N	73°56'W		x	
1925 E	"	Windsor, Conn.	41°52'N	72°38'W		x	
1925 F	24 Jan 1925	North Scituate, Rhode Island	41°45'N	71°35'W		x	
1925 G	"	Mt. Beacon, New York	41°31'N	73°59'W		x	
1925 H	"	New Haven, Conn.	41°52'N	72°58'W		x	x
1925 I	"	Martha's Vineyard, Mass.	41°25'N	70°35'W		x	
1925 J	"	Welland, Ontario	42°59'N	79°14'W			x
1925 K	"	Middletown, Conn.	41°34'N	72°39'W			x

Table 1 (Contd.). Eclipse Information Available

1925 L	24 Jan 1925	Between Wallingford & New Haven, Conn.	41°52'N	72°58'W		x	x
1926 A	14 Jan 1926	Jubaland					x
1926 B	"	Benkoelen, Sumatra			x		
1927 A	29 June 1927	Giggleswick					x
1927 B	"	Yorkshire, England					x
1927 C	"	Olliver Ducket, Richmond, Yorks	54°24'N	1°44'W			x
1927 D	"	Ringebu, Norway	61°30'N	10°12'E			x
1927 E	"	Criccieth, Wales	52°55'N	4°14'W	x		
1927 F	"	Southport, England	50°36'N	4°24'W	x		
1927 G	"	Leyburn, England	54°19'N	1°49'W	x		
1929 A	9 May 1929	Alor Star, Malaya	6° 6'N	100°23'E	x		
1930 A	21 Oct 1930	Nivafou	15°36'S	175°39'W	x		
1932 A	31 Aug 1932	Lancaster, New Hampshire	44°29'N	71°34'W	x		
1936 A	19 June 1936	Aboard ship	37° 8'N	23°30'E		x	x
1936 B	"	Bartat, Russia			x		
1937 A	8 June 1937	Canton Island	2°50'S	171°40'W	x		
1937 B	"	Pacific Ocean	9°49'S	133°38'W		x	x

Table 1 (Contd.). Eclipse Information Available

1937 C	8 June 1937	Moro, Peru	10°43'S	76°15'W		x	
1940 A	1 Oct 1940	Calvinia, South Africa	31°25'S	19°47'E		x	x
1940 B	"	Patos, Brazil	6°55'S	36°15'W	x		
1941 A	21 Sept 1941	Alma Ata, Russia	43°19'N	76°55'E	x		
1947 A	20 May 1947	Araxa, Brazil	19°37'S	46°50'W	x		
1947 B	"	Bocaiuva, Brazil	17° 8'S	43°54'W	x		
1952 A	25 Feb 1952	Jebel Dabachi	18°32'N	35°33'W	x		
1952 B	"		41°15'N	$4^h\ 5^m$E	x		
1952 C	"	Aircraft over the Red Sea			x		
1954 A	30 Jun 1954	Aircraft	61°24'N	1°35'W	x		
1954 B	"	Syd Koster, Sweden			x		
1954 C	"	Fairplay, Colorado	39°13'N	106° 0'W	x		
1954 D	"	Grebbestad, Sweden	58°42'N	11°15'E	x		
1959 A	2 Oct 1959	Kidal Tanout } French West Africa	18°27'N 14°55'N	1°25'E 8°49'E	x		
1961 A	15 Feb 1961	Aircraft near Rostov	57°11'N	39°23'E	x		
1961 B	"	Bucharest, Rumania	44°25'N	26° 7'E	x		
1961 C	"	Viareggio, Italy	43°52'N	10°15'E	x		
1963 A	20 Jul 1963	Aircraft near Great Slave Lake, Can.	61°25'N	117°30'W	x		

Table 1 (Contd.). Eclipse Information Available

1963 B	20 Jul 1963	The Forks, Maine			x
1963 C	"	Aircraft over Canada			x
1963 D	"	Balloons over Maine			x
1963 E	"	Hermon, Maine			x
1963 F	"	Aircraft near Fort Providence			x
1965 A	30 May 1965	Aircraft near Bellingshausen, Atoll			x
1966 A	12 Nov 1966	Quehua, Bolivia	20.12°S	66.95°W	x

3. STAR SIGHTINGS

The presence of stars and, occasionally, comets has been noted in eclipse descriptions for centuries. The location of ancient eclipses is important for the determination of the secular motion of the moon, and the closeness to totality of an eclipse as indicated by the presence of stars has figured in discussions of this problem. Almost no deliberate attempts at star observations during solar eclipses have been made, the exceptions having been initiated by Fotheringham.[10] It would appear that more could be done in this direction in coming eclipses occurring in well-populated regions. In any event, observations and notations of star sightings seem to have been more the result of chance. Venus and Mercury are often observed, and this is most likely the result of their being in the neighborhood of the sun, which is the object at the center of attention during an eclipse. A listing of identified stars and planets is given in Table 2, together with their magnitudes.

The brightness of an ambient field can be determined, in principle, from the magnitude of a point source which can just be detected in this field. Both theory and experiment are in reasonable concurrence for the case of star visibility during twilight and during daylight (see, for example, Tousey and Koomen,[11] Hardy,[12] and Horman[13]).

For the average total solar eclipse, theory would predict the visibility at the zenith of stars of about the third magnitude. For actual eclipses for which stellar magnitudes can be derived, however, third magnitude stars are observed in only five cases. Thus for photometric purposes we must rule out observations of stars during eclipses. It might appear that those few instances in which third magnitude stars were observed would, by comparison, qualify as dark eclipses. This appears certainly to be true for the eclipse of 1886. The others, however, appear to be of ordinary brightness. Thus for 1842, 1860 and 1940, letters of medium or small size could be read. For the 1937 eclipse observers in the Pacific noted only the brighter stars, while an observer in Peru noted stars down to the third magnitude. The solar elevation angle in Peru was about 9-10°, and this would result in at least a five fold decrease in intensity (Sharp[7]). In addition, the elevation of the station would also reduce the intensity somewhat. The result of these factors could easily reduce the brightness sufficiently below that of the noon point (the

10. Fotheringham, J.K. (1921, 1925) Historical Eclipses, Oxford: Clarendon Press, 1921; Visibility of stars in Great Britain during the solar eclipse of 24 January 1925, Monthly Notes Roy. Astrophys. Soc. 85:509-510.

11. Tousey, R., and Koomen, M.J. (1953) The visibility of stars and planets during twilight, J. Opt. Soc. Am. 43:177-183.

12. Hardy, A.C. (1967) How large is a point source? J. Opt. Soc. Am. 57:44-47.

13. Horman, M.H. (1967) Visibility of light sources against a background of uniform luminance, J. Opt. Soc. Am. 57:1516-1521.

Table 2. Star Sightings

Identification Number	Eclipse Date	Location	Stars Observed	Apparent* Visual Mag.
-1375A	3 May 1375 B.C.	Ugarit, Syria	Either Aldebaran	1.1
			or Capella	0.2
1699A	13 Sept 1699	Nurenburg	Venus& no others	-4
1706A	12 May 1706	Geneva, Switzerland	More than 16 stars	
1706B	"	Marseilles, France	3 stars	
1706C	"		Venus	-4
			Mercury	-1.2
			Saturn	-0.5
			Aldebaran	1.1
			Other stars not named	
1715A	22 Apr 1715	Upsala, Sweden	Jupiter	-3
			Mercury	-1.2
			Venus	-4
			Cassiopea	
			Capella	0.2
			Oculus Tauri	
			Orion	
1715B	22 Apr 1715	London, England	Jupiter	-3
			Mercury	-1.2
			Venus	-4
			Capella	0.2
			Aldebaran	1.1
			Not less than 20 stars	
1715C	22 Apr 1715		Several stars of the second magnitude	
1724A	22 May 1724	Amesbury, England	Venus & no others	-4

*Apparent visual magnitudes listed for the planets are maximum and do not take into consideration the relative position of the planet at the time of the eclipse.

Table 2 (Contd.). Star Sightings

1724B	22 May 1724	Paris, France	Mercury	-1.2
			Venus	-4
			Capella	0.2
			Several fixed Stars	
1778A	24 June 1778	Ship at sea	Stars of the first & second magnitude	
1806A	16 June 1806	Kinderhook, N. Y.	5 or 6 principal stars & planets	
1806B	16 June 1806	Salem, Mass.	Capella	0.2
			Aldebaran	1.1
			Sirius	-1.6
			Procyon	0.5
			δ Orionis	2.5
			ε Orionis	1.8
			ζ Orionis	2.1
			α Orionis	Variable
			Venus	-4
			Mars	-3
1834A	30 Nov 1834	Beaufort, South Carolina	Antares	1.2
			Two planets & 3 other stars of the first magnitude	
1842A	8 July 1842	Venice, Italy	Capella	0.2
			Aldebaran	1.1
1842B	8 July 1842	Perpignan, France	4 or 5 stars	
1842C	"	On the sea shore	7 to 10 stars	
1842D	"	Narbonne, France	up to 10 stars	
1842E	"	Montpellier, France	Not more than 5 stars	

Table 2 (Contd.). Star Sightings

1842F	8 July 1842	Digne, France	Capella	0.2
			β Tauri	1.8
			ζ Tauri	3.0
			γ Orionis	1.7
1842G	8 July 1842	Lodi, Italy	Mars	-3
			2 stars of Gemini	
			Aldebaran	1.1
			Capella	0.2
			Other stars of first magnitude	
1842H	8 July 1842	Novara, Italy	Mars	-3
			Capella	0.2
			Aldebaran	1.1
1843A	21 Dec 1843	Parratt	Venus	-4
			Saturn	-0.5
			Arcturus	0.2
1860D	18 July 1860	Palmas, Spain	Jupiter	-3
			Venus	-4
			Others	
1860E	18 July 1860	Rivabellosa, Spain	Jupiter	-3
			Venus	-4
			Castor	2.0
1860G	18 July 1860	Vitoria, Spain	4 planets	
			8 stars of 3rd mag.	
			Jupiter	-3
			Venus	-4
			Saturn	-0.5
			Mercury	-1.2
			Castor	2.0
			Pollux	1.2
			Regulus	1.3
			Capella	0.2
			β Aurigae	2.1
			Procyon	0.5
			β Canis Minoris	2.0
			γ Leonis	2.6
1868B	18 Aug 1868	Siam	Sky was studded with stars	

Table 2 (Contd.). Star Sightings

1868C	18 Aug 1868	Barram Point, Borneo	9 stars Venus	 -4
1868F	18 Aug 1868	Mantawalu Kiki, Celebes	β Leonis Regulus	2.2 1.3
1869A	7 Aug 1869	Mattoon, Illinois	Mercury Arcturus Vega	-1.2 0.2 0.1
1869C	7 Aug 1869	Des Moines, Iowa	Saturn Antares 2nd mag. stars Venus Mercury	-0.5 1.2 -4 -1.2
1869D	7 Aug 1869	Bristol, Tennessee	Mercury Venus Saturn	-1.2 -4 -0.5
1869E	7 Aug 1869	Springfield, Illinois	Mercury Venus Saturn Arcturus Vega Antares Altair Benetnasch	-1.2 -4 -0.5 0.2 0.1 1.2 0.9
1869I	7 Aug 1869	36°35'N 82°9'W	Mercury Regulus	-1.2 1.3
1869J	7 Aug 1869	White Top Mountain, Virginia	Venus Mercury	-4 -1.2
1869K	7 Aug 1869	Plover Bay, Siberia	Mercury	-1.2
1870A	22 Dec 1870	San Antonio	Venus alone	-4
1875A	6 Apr 1875	Bangkok, Siam	Only 4 stars	
1878B	29 July 1878	Denver, Colorado	Mercury Regulus Mars Venus Procyon Several other stars	-1.2 1.3 -3 -4 0.5

Table 2 (Contd.). Star Sightings

1880A	11 Jan 1880	Santa-Lucia	Jupiter Mars No stars	-3 -3
1882A	17 May 1882	Sohag, Egypt	Stars shone brightly	
1883A	6 May 1883	Caroline Island	Saw stars down to 6th magnitude with a telescope	
1885C	9 Sept 1885	Woodstock, New Zealand	Jupiter Other stars	-3
1886B	28-29 Aug 1886	Grenada	3rd or 4th mag. stars	
1886D	"	West Indies	Great number of stars	
1887A	19 Aug 1887	Steglitz, Germany	α Persei	1.9
1887G	"	Mount Blaghodat, Russia	Venus Mercury Mars α Leonis	-4 -1.2 -3 1.3
1887I	19 Aug 1887	Elpatievo Narishkine	Regulus Mercury	1.3 -1.2
1889A1	1 Jan 1889	Liegan, California	Several stars	
1893B	16 Apr 1893	Fundium, Senegal	Jupiter Venus	-3 -4
1896A	9 Aug 1896	Orlovski, Russia	Several stars of 1st magnitude	
1896B	9 Aug 1896	Bodo, Norway	Jupiter Venus Mercury Regulus	-3 -4 -1.2 1.3

Table 2 (Contd.). Star Sightings

1896C	9 Aug 1896	Aboard ship	Jupiter Mercury Venus Many well known constellations	-3 -1.2 -4
1898A	22 Jan 1898	Viziadrug, India	Venus Mars 3 stars	-4 -3
1898B	22 Jan 1898	Jeur, India	2 stars only	
1898C	"	Talni, India	Mars Venus 2 or 3 stars	-3 -4
1900A	28 May 1900	Ovar, Portugal	Venus Mercury Sirius	-4 -1.2 -1.6
1900B	28 May 1900	Elche, Spain	Venus Mercury Sirius	-4 -1.2 -1.6
1900C	28 May 1900	Juliette, Georgia	Mercury Another heavenly body	-1.2
1900D	28 May 1900	Norfolk, Virginia	Mercury	-1.2
1900G	28 May 1900	Barnesville, Georgia	Mercury	-1.2
1900H	28 May 1900	Washington, Georgia	Mercury Venus	-1.2 -4
1901B	17 May 1901	Solok, Sumatra	Mercury Venus	-1.2 -4
1905B	30 Aug 1905	Guelma, Algeria	Mercury Venus Regulus	-1.2 -4 +1.3
1905C	30 Aug 1905	Alcala de Chisvert, Spain	Venus only	-4

Table 2 (Contd.). Star Sightings

1905E	30 Aug 1905	Ship in the Mediterranean	Venus	-4
			Regulus	1.3
1905F	30 Aug 1905	Burgos, Spain	Mercury	-1.2
			Venus	-4
1905H	30 Aug 1905	Porta Coeli, Spain	Venus	-4
1905I	30 Aug 1905	Ship off Capricorn, Spain	Venus	-4
1908A	3 Jan 1908	Flint Island	Mercury	-1.2
			Venus	-4
1912B1	17 Apr 1912	St. Germain-en-Laye, France	Mercury	-1.2
			Venus	-4
1912C1	17 Apr 1912	Olhomarinho, Portugal	Mercury	-1.2
			Venus	-4
1912F1	17 Apr 1912	Paris, France	Venus	-4
1914B	21 Aug 1914	Minsk, Russia	Regulus	1.3
			Mercury	-1.2
			Venus	-4
1914C	21 Aug 1914	Hernösand, Sweden	Mercury	-1.2
			Venus	-4
1918C	8 Jun 1918	U.S.S. Dixie off Bona, Algeria	Venus	-4
			Castor	2.0
			Pollux	1.2
			Regulus	1.3
1922A	21 Sept 1922	Stanthorpe, Queensland	Venus	-4
			Mercury	-1.2
			Jupiter	-3
			Spica	1.2
			α Centauri	0.1
			β Centauri	0.9
1925B	24 Jan 1925	Saugerties, N.Y.	Venus	-4
			Jupiter	-3
			Mercury	-1.2
			2 brighter stars	

Table 2 (Contd.). Star Sightings

1925C	24 Jan 1925	Guilford, Conn	Jupiter	-3
			Venus	-4
			Mercury	-1.2
			Vega	0.1
			α Aquilae	0.9
			ε Cygni	2.6
1925D	24 Jan 1925	Poughkeepsie, N. Y.	8 stars	
1925E	"	Windsor, Conn	3 planets & 6 stars	
			Saturn	-0.5
			Vega	0.1
			Altair	0.9
			Deneb	1.3
1925F	24 Jan 1925	North Scituate, R. I.	Venus	-4
			Jupiter	-3
			Mercury	-1.2
			Vega	0.1
			Altair	0.9
1925G	24 Jan 1925	Mt. Beacon, N. Y.	3 planets & no stars	
1925H	"	New Haven, Conn.	Venus	-4
			Mercury	-1.2
			Jupiter	-3
			ε Pegasi	2.5
			ε Cygni	2.6
			α Aquilae	0.9
			Vega	0.1
			Arcturus	0.2
1925I	24 Jan 1925	Martha's Vineyard, Mass.	Venus	-4
			Mercury	-1.2
			Jupiter	-3
			α Aquilae	0.9
1925L	24 Jan 1925	Between Wallingford & New Haven, Conn.	Saturn	-0.5
			3 to 7 stars	
1936A	19 June 1936	Aboard ship	Mars	-3

Table 2 (Contd.). Star Sightings

1937B	8 June 1937	Pacific Ocean	Venus	-4
			Mercury	-1.2
			Sirius	-1.6
			Betelgeuse	Variable
			Procyon	0.5
			Capella	0.2
1937C	8 June 1937	Moro, Peru	Mars	-3
			Canopus	-0.9
			Sirius	-1.6
			α Crucis	1.1
			β Crucis	1.5
			δ Crucis	3.1
			γ Crucis	1.6
			Stars down to the 3rd magnitude	
1940A	1 Oct 1940	Calvinia, South Africa	Mercury	-1.2
			Spica	1.2
			Arcturus	0.2
			Antares	1.2
			α Crucis	1.1
			β Crucis	1.5
			δ Crucis	3.1
			γ Crucis	1.6
			Pointers to the Southern Cross	

Pacific observations) so that third magnitude stars could become visible. Hence we conclude that the main lesson to be learned from reports of star sightings during total solar eclipses is that when good observers are present, the results are in accord with those to be expected from more quantitative measurements. The principle of the method nevertheless seems sufficiently sound to be perhaps worth pursuing on a more systematic basis in future eclipses.

I. RANK ORDERING

Over the past century the increasing ease of travel has led to the observation of several eclipses by the same observer, and at least subjective comparisons of the comparative brightness of the eclipses are available. These are listed in Table 3, the inequalities being indicated for either darkness or lightness, as in the original report. We have not attempted a complete rank ordering of all of the eclipses mentioned because of insufficient data. The eclipse of 1886, however, seems clearly to have been the darkest. The eclipses from 1898 to 1905 seem to

Table 3. Comparisons of Different Eclipses

Identification Number	Observer	Lightness	Darkness
1860 I	Struve		<1842
1860 J	Airy	>1842, 1851	
1870 BB	Hall		≲1869
1870 CA	Parsons		≲1860
1883 B	Woods		little less than Egypt (1882)
1886 BB	Tacchini		>1883
1889 ClB			>1886, 1887
1893 B	Abney & Thorpe		<1886
1900 A		≈ 1898	
1900 EB	Himes		<1869
1901 A	Maunder	1900 > 1898, 1901 1886; 1898 ≈ 1901	1886 darkest
1905 C	Moye	>1900	
1905 D	Campbell & Perrine		>>1898, 1900; >1901
1908 AA	Campbell		<1898, 1900, 1905
1926A	Mengarini		<1905, 1914

have been of roughly comparable magnitude, especially those of 1898, 1900 and 1901. Qualitatively, at least, it would appear that a major influence on the brightness would be dust in the atmosphere, since light from distant regions would suffer high extinction because of the long path length in a dusty atmosphere. Solar radiation intensity should also reflect the dust content, and we may therefore hope for a correlation between eclipse brightness and this quantity. Data for solar radiation intensity from 1883 to 1918 are plotted by Kimball (1918). The mean intensity decreased from 1883 to 1885, presumably due to dust from the Krakatoa volcanic eruption, and then increased in 1886 and 1887. Minima in these years, however, occurred in the late summer and early fall, indicating a possible seasonal effect. The eclipse of 1886 was in late August so that it occurred near the minimal radiation intensity for the year. In accordance with our hypothesis, the radiation intensity at this time was much lower than that at the appropriate times for the eclipses of 1898-1905. These latter, furthermore, would be of comparable magnitude, as they are, the radiation intensities being relatively constant over the period. The eclipse of 1908, however, would be expected to be darker than observed. The explanation for the discrepancy seems to us to be that the radiation intensities are based entirely on northern hemisphere stations, while the 1908 eclipse was observed at Flint Island, south of the equator. This suggests interhemispheric differences in the circulation of the dust layers of the lower atmosphere. Some support for this comes from the greater than expected brightness of the 1885 eclipse, observed in New Zealand, which occurred near the time of the lowest radiation intensity of the 1883-1918 period as measured at the northern stations. Taking account of this, and comparing the 1885 eclipse with that of the following year observed in the Caribbean, it appears likely that the Krakatoa dust of 1883 had by 1885 been largely transferred to the northern hemisphere, and had then slowly settled over the next few years.

5. TWILIGHTS

Comparison of the sky brightness with the twilight sky at some solar depression angle has proven useful in photometric work. The review of this work (see Section 4) has shown that typically the equivalent solar depression angle is 5^{o} - 5.5^{o}. Eleven of the accounts collected here can be referred to twilight in one way or another. Of these two are vague, a "medium twilight" (1910 - Tasmania) and a "late twilight" (1925-Amherst expedition). One observer (1811), making a "random conjecture" estimated 6^{o}-8^{o}, somewhat darker than one would expect, but within a reasonable error for such an estimate. Otto Struve, of the family of famous astronomers, estimated the light by comparison with the twilight at about

the summer solstice at the latitude of St. Petersburg. His approximate times give equivalent solar depression angles of about 6.5^{o} for the 1842 eclipse, and 5.5^{o} for the 1860 eclipse. The results, on the low side of what might be expected, are not unreasonable. One comparison (1870 - Oran) estimates the equivalent twilight as about 1 hour after sunset. This corresponds to a solar depression angle of about 11^{o} and is clearly in error and unreliable. One other estimate, about one-half hour after sunset (1887 - Chlamostino), corresponds to a solar depression angle of about 4^{o}, and, while more reasonable, is still unreliable in view of the rapid change in twilight intensity with time in that region.

A reasonably quantitative measurement was carried out by Prof. Albrecht at Goldap, E. Prussia, during the eclipse of 1887. The account is: "During totality he noted the greatest distance at which he could read a certain manuscript written with a lead pencil, and in the evening he watched for the time when the same manuscript was again just legible at the same distance, and found it to be 40 minutes after sunset. Fortunately the condition of the sky with respect to cloudiness was the same in the evening as during the eclipse." The resulting solar depression angle is 5.5^{o} and is in accord with photometric results.

Two measurements appear to be by comparison with photographic plates taken during twilight, though the text is not completely unambiguous. In one (1889 - Sierra Nevadas) using photographs of trees on a snow covered mountain about fifteen miles away, the darkness was found to be equivalent to that 40 minutes after sundown, or a solar depression angle of 7^{o}. The other comments from California parties are contradictory, one noting that no artificial light was necessary for sketching, the other that it was. The solar radiation intensity was at a minimum for the year in January 1889. In the other, in Sobral, Brazil (1919), photographic plates were exposed for comparison with those on the eclipse day. These showed "that exposure was possible up to 25 minutes before sunrise, when the sky was of about the same brightness as during totality". It is not clear whether the comparison was based on visual observation or on the plates. In any event the equivalent solar depression angle is 6.2^{o}, somewhat darker than is typical.

Finally, we note two observations which depend not so much on the twilight intensity itself as on the rate of change of this intensity. In one (1869 - Des Moines) it is noted that "the totality ... was about equal to that on a clear moonless evening, at the time when third-magnitude stars can be easily seen". Examination of a curve of stellar magnitude versus solar depression angle (derived from the work of Tousey et al[11] indicates that this should be in the neighborhood of 5.5^{o} - 6^{o}, which is a reasonable value. In the other observation (1860 - Rivabellosa) it was noted that "By subsequent trials he was led to conclude that the light during a total eclipse most resembles that degree of illumination which exists in a clear sky soon after sunset, when, after having made out a first

magnitude star, other stars of less brilliancy can be discerned one after another by an attentive gazer". This would correspond perhaps most closely to the region from 3^{o} - 6^{o} solar depression angles, where the rate of change is greatest. The eclipse seems certainly to have been a bright one, since instrumental gradations and print were clearly visible, but it is unlikely that it could have been bright enough to correspond with a 3^{o} or 4^{o} solar depression angle. Struve, as we have noted earlier, estimated a twilight equivalent for this same eclipse which corresponds to about 5.5^{o} solar depression angle.

Summary: Where the observer has been careful or is very experienced, the twilight equivalent of the sky brightness is of the same order as those for more recent eclipses for which photometric comparisons are available. There appears to be a tendency for the visual comparisons to give a somewhat later twilight time than might be expected. This may be a real effect and dependent on psychophysical factors resulting from color changes during twilight and totality, but we have not explored this possibility in any detail. Estimates of absolute intensity from these twilight equivalents when dust is present in the atmosphere are also difficult. Both involve the passage of light through long path lengths with, however, considerably different geometries. We have therefore not attempted even an estimate of the sense of the variation of intensity from one eclipse to another, and leave the question unresolved.

6. COMPARISONS WITH MOONLIGHT

Nineteen of our excerpts compare the darkness with some aspect of moonlight or the absence thereof. The brightness at totality is of the order of 10^{-3} that of the day sky, while the full moonlight is of the order of 10^{-6} that of the day sky, so that the sky brightness during totality is of the order of 10^{3} that during full moon. Consequently, any observation that indicates a sky brightness of the order of magnitude of moonlight or less must be more indicative of psychophysical effects than of photometric reality.

Seven of our references (1860-Rivabellosa; 1900 D; 1900 EC; 1900 Elche; 1925 Middletown; 1927 Richmond; 1927 Ringebu) recognize that the illumination was much greater than that of full moonlight. One (1905 Alcocebre) estimates a brightness ten times that of a full moon, but this must, of course, be considerably less than the true value. Eight make comparisons to the moon in various phases. Of these, two (1875; 1883 Caroline (Nature)) set the brightness as that of the full moon, two (1806; 1886 AB Carriacou) as darker than this. One (1925 New Haven) sets it equal to one and one half full moons. One (1878 Rawlins) sets it equal to a 10 day old moon; one (1885 Wellington) to the moon in the first quarter; and one

(1885 Nelson) to a half-full moon. Two (1887; 1910 AA) give the brightness as that of a moonless night. One (1869 Des Moines) is essentially correct in comparing the brightness to that of a clear, moonless evening when third magnitude stars can be easily seen.

These references thus are of more interest from a psychophysical point of view than as an indicator of the actual brightness. It is possible that the moon acts to produce a dazzle field and thus gives an impression of greater brightness than is actually present. It is also possible that the presence of the corona at the center of the stage, and the knowledge of the obscuring moon, leads to comparison with moonlight. Whatever the reason, whether these or others, discussion of this interesting question lies outside the scope of the present publication, and we do not pursue it further here.

7. VISIBILITY OF PRINTED OR WRITTEN LETTERS, INSTRUMENT PARTS, AND OBJECTS

By far the most common type of comments from which some idea of brightness can be inferred are those dealing with the visibility of objects. These can be other persons or their features, parts of the body, and occasionally such objects as furniture. With the spread of scientific observation and the consequent need to read dials, watches, and printed or written instructions for the operation of equipment, the comments tended to deal with these aspects. In only a few cases were different sizes of print deliberately read in order to obtain some indication of brightness. In Table 4, we have summarized comments in these categories for the different eclipses.

We have not attempted to convert these to brightness, even where fairly detailed measurements are given, as for the eclipses of 1922 and 1927 (1922-BB; 1927-D).

Where several comments are found for the same eclipse, even though the locations are different, they tend to be consistent. Thus for the eclipse of 1900 the accounts agree that print and the divisions of a watch could be seen without any artificial light. Similarly, for 1870, the chronometer divisions could be easily seen and sketching carried on. It is, however, noted that there was difficulty in reading a few words of "a type nearly as large as that employed in the footnotes of 'The Observatory'". This statement does not seem inconsistent with the preceding. For the eclipse of 1887, on the other hand, at four locations both print and chronometers could not be read without artificial light, while at one (Chlamostino) the second hand of a watch could easily be placed. We may note that the greater than average darkness at this eclipse is in accord with our hypothesis that the darkness will be greater as the attenuation of sunlight, presumably caused

Table 4. Visibility of Print, Instrument Parts, Objects

Identification Number	Date of Eclipse	Location	Visibility
1560 A	1560		could not see the foot
1706 A	12 May 1706	Geneva	impossible to read
1715 A	22 Apr 1715	Upsala	could not distinguish each other
1842 G	8 Jul 1842	Lodi	read characters of medium size
1843 A	21 Dec 1843	Parratt	never quite dark or too dark to read off the actinometer
1851 A	28 Jul 1851	Bue Island Norway	small print could be read
1851 B	"	Frederiksvaern	could read the face of a box chronometer
1851 C	"	Christiania	not easy to decipher the figures of a watch in hand
1851 E	"	Trollhattan	"could neither see the seconds hand of my watch, nor the paper sufficiently to write the time down"
1851 F	"	Christianstadt	some difficulty reading the seconds of the chronometer
1851 G	"	Gottenburg	unable to read the minutes of the chronometer, or to make out a circle
1858 A	15 Mar 1858	Scotland-England	could not read the instruments
1870 CA	18 Jul 1860	Nisqually	lamp needed to read white-faced chronometer [see Parsons 1870]
1860 A	"	N. W. Brit. America	title page of the Nautical Almanac could be read with facility
1860 B	"	Labrador	no difficulty reading lines written in pencil

Table 4 (Contd.). Visibility of Print, Instrument Parts, Objects

1860 C	18 Jul 1860	Washington Terr.	impossible to recognize the seconds dial of the chronometer
1860 D	"	Mt St-Michel Spain	could distinguish small objects, & read without difficulty
1860 F	"	Burgos, Spain	in the rooms: afraid of running against the furniture
1860 G	"	Vitoria	could distinguish objects, read the finest writing, & the scale of the thermometer
1860 H	"	St Lorenzo Mt.	could see the divisions of the thermometer, but not the Hg
1860 J	"	Herena	could read a chronometer face at 12 inches
1868 A	18 Aug 1868	Beejapoor	could easily write, read & read seconds of our watches
1868 A	"	" (in town)	could not see ones own hand
1868 B	"	Siam	at a few feet distance a persons features were indiscernible, the thermometers could not be read
1868 C	"	Borneo	could not mark the protuberances in a notebook
1868 D	"	V mpurthy	could not recognize the face of a person within a distance of 3 yards
1868 E	"	Wha-Tonne	in open air: could easily distinguish the characters of writing; in hut: needed a lamp to read the drums of a micrometer
1869 B	7 Aug 1869	Ottumwa, Iowa	too dark to adjust the exposure slide
1869 H	"		seconds on watch faces could not be read
1870 A	22 Dec 1870	San Antonio	darkness never sufficient to prevent sketching with comfort

Table 4 (Contd.). Visibility of Print, Instrument Parts, Objects

1870 BA	22 Dec 1870	Syracuse	a large dialled chronometer could be read in the open; inside: could not find pieces of glass on the table
1870 CA	"	Gibraltar	could see chronometer divisions distinctly at a distance of 8"
1870 D	"	Jerez	difficulty in reading a few words of very distinctly printed matter, of a type nearly as large as that employed in the footnotes of the "observatory"
1870 F	"	Oran	never too difficult to see the seconds on the face of a watch
1871 A	12 Dec 1871	Australia	newspaper print could be read without much difficulty
1875 A	6 Apr 1875	Bangkok	could draw, write and read; could read a small watch 1 1/2 ft from his face inside a shed
1878 A	29 Jul 1878	Rawlins	could read the circles
1878 B	"	Denver	could see fine pencil lines
1882 A	17 May 1882	Sohag	could read a rather closely graduated thermometer
1885 A	9 Sep 1885	Wellington	watch face could be easily read
1886 AA	29 Aug 1886	Carriacou I.	bright enough to read the programme written in a bold round hand
1887 A	19 Aug 1887	Steglitz	chronometer could only be read with difficulty
1887 C	"	Kleistshohe	lanterns required in order to read
1887 D	"	Kolmar	could not read watch face without artificial light
1887 G	"	Mt Blaghodat	neither notes nor chronometer could be read without a lantern
1887 H	"	Chlamostino	second hand of a watch could easily be placed

Table 4 (Contd.). Visibility of Print, Instrument Parts, Objects

1889 A1	1 Jan 1889	Liegan	watch could be read and drawing made
1889 C1A	"	Chico	necessary to use artificial light for sketching
1889 A2	22 Dec 1889	Cape Ledo	chronometer minute and hr hands could be seen at 8' distance, and second hand at 3'
1893 A	16 Apr 1893	Mina Bronces	second hand of a watch easily seen
1898 A	22 Jan 1898	Viziadrug	newspaper print easily read; second hand position seen without lantern
1900 A	28 May 1900	Ovar	as bright as 1898 when newspaper read without artificial light
1900 B	"	Elche	all objects distinctly seen, divisions of a watch or newspaper read without artificial light
1900 C	"	Juliette	see pencil lines on drawing board
1900 EA	"	Virginia Beach	ordinary print read without difficulty
1900 EC	"	"	sufficient for reading fine print
1900 H	"	Washington, Ga.	plenty of light to read the chronometer
1901 BB	17 May 1901	Solok	sufficient light to read the face of a chronometer or an ordinary printed page without difficulty
1905 C	30 Aug 1905	Alcala de Chisvert	no difficulty drawing or reading small letterpress; landscape features, divisions of a watch all seen easily
1905 D	"	Alhama	had to look closely to distinguish the figures in a table of logarithms
1905 G	"	Daroca	ordinary print could be read
1908 AB	3 Jan 1908	Flint Island	never became too dark to read large figures; newspaper could be read without difficulty
1922 BA	21 Sep 1922	Wallal	lamps needed for plate changing

Table 4 (Contd.). Visibility of Print, Instrument Parts, Objects

1922 BA	21 Sep 1922	Wallal	pica or 12-pt old style easily read; bourgeois, or 9-pt rather hard; nonpareil antique, or 6-point - very hard; pearl or 5-point not at all; when a candle was 2 ft away, illumination equal to middle of eclipse
1923 A	10 Sep 1923	Airplane	sufficient light to read instruments
1925 J	24 Jan 1925	Welland	ordinary print could not be read but hands of a watch could be seen
1925 L	"	New Haven	easy reading of type on printed folders which had been read with difficulty two weeks earlier on bright moonlit nights; watch faces easily read
1926 A	14 Jan 1926	Jubaland	sufficient to read chronometers & marks on plate holders
1927 A	29 Jun 1927	Giggleswick	flashlight needed to read chronometer
1927 D	"	Ringebu	could read type 0.5 mm high while 2 mm was the minimum in full moonlight
1936 A	19 Jun 1936	Aboard ship	print and graduation on instruments read easily
1937 B	8 Jun 1937	Aboard ship	ordinary print read easily
1940 A	1 Oct 1940	Calvinia	no difficulty reading the exposure times written on cardboard

by atmospheric dust, is greater. For 1887, as for 1886 and 1885, a minimum in the solar radiation intensity in the northern hemisphere occurred in the summer or late summer (see Figure 1).

If we consider those eclipses for which multiple comments are available we can divide them into two groups, dark and light, the criterion for classification being whether print, dials, objects, etc., can or cannot be distinguished. On this basis only one, that of 1887, is dark. Those of 1860, 1870, 1878, 1900 and 1905 are light. Three others, 1851, 1868 and January 1889, include comments in both categories. The reasons for this are not clear, though it is possible that these were in an intermediate brightness range and that local conditions determined whether the threshold of print visibility was exceeded or not. We may note that the solar radiation intensity in the northern hemisphere in January 1889 was the minimum value for 1888-1889, though it was not as low as the minimum for 1887, or the two years preceding that. The solar radiation intensity for the eclipse of January 1908 was only slightly higher than for January 1889, but the eclipse was nevertheless a bright one by our criterion. As we have noted earlier this was probably due to the observation site in 1908 being in the southern hemisphere.

An interesting special case is that of the eclipse of April 1912, which was observed in western Europe. The eclipse was annular, with the possibility that it was total for a fraction of a second in Portugal. Baily's Beads were seen so that the eclipse was perhaps between annular and total, and one writer suggested that this could represent a new type of eclipse, which he called "perlee" or a pearled eclipse. It is difficult, however, to estimate the brightness of the eclipse. It was noted that Mercury and Venus, but no stars, were visible. Comments on the darkness are conflicting. Observers in a balloon at 800-900 meters height noted that they were able to read a thermometer and a chronometer. These comments taken together would indicate a light or at least average eclipse, provided that the

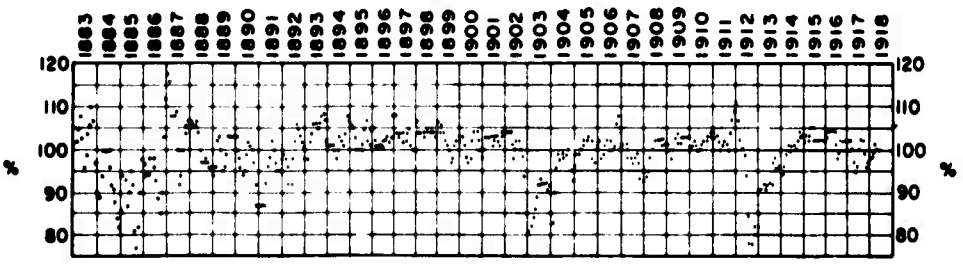


Figure 1. Monthly Averages of Solar Radiation Intensity at Earth's Surface, Expressed as Percentages of the Monthly Normals

solar obscuration is greater than 99.9 percent. We are not aware of any precise definition of the solar obscuration corresponding to the visual phenomenon of Baily's Beads. Photographs (see [14]) sometimes show both Baily's Beads and the inner corona, and this would indicate a greater than 99.9 percent obscuration. The human observer would, however, not be likely to see both because of the dazzle effect of the point sources of light and insufficient time for dark adaptation. Of the comments noted above perhaps the only one useful as an indicator of the brightness is that in which thermometer and chronometer could be read, and this would favor a bright eclipse, in our use of the term. Finally, we may note that for the most recent eclipse in this series, that of 20 May 1966, photographs show a "diamond necklace" effect but no corona. A lightmeter reading for this eclipse gave a value for the illumination at mideclipse of 0.001 of its value before first contact. [15] We are thus dealing with the region in which the interesting phenomena appear but in which conclusions are difficult to come to with any great confidence.

For many eclipses only a single comment is available, and any conclusions on the basis of this comment must be considered as tentative only. Applying our criterion the eclipses of 1858 and 1869 would be dark, as well as, on an even more tentative basis, the eclipses of 1560, 1706, and 1715. Average or light eclipses were those of 1843, 1871, 1875, 1882, 1885, December 1889, 1893, 1898, 1908, 1925, 1936, 1937, and 1940. Comments are available for two more eclipses, those of 1922 and 1927, from which some estimate could be derived but we have not attempted this and leave these as doubtful.

8. MISCELLANEOUS

A listing of miscellaneous observations which do not fit into the preceding categories is given in Table 5. Some few are general comments indicative of the surprise of the observer at the brightness being greater than expected, or of a comparison with past eclipses, as that the eclipse of 1886 was the darkest eclipse since eclipse records have been in vogue. Some of the comments could possibly be converted to brightnesses, such as that for 1851, that the shadow of a taper was imperceptible when the taper was 193 inches from the screen, or the comments on the visibility of distant objects. We have, however, not attempted these conversions and merely list the comments.

Perhaps the most exotic, and certainly one of the more interesting, proposals for photometry of the eclipsed sky was made by Arago (1843). He noted that during the eclipse certain plants closed their leaves during totality while others remained

14. Sky and Telescope (1970) 39:286-287.
15. Sky and Telescope (1966) 32:80-83.

Table 5. Miscellaneous Observations

Identification Number	Location	Observations
1715 B	London	might have expected more stars
1842 A	Venice	chimney smoke not visible
1851 A	Bue Island	sufficient to make a ship stop its course and furl its sails
1851 D	Gottenburg	shadow of taper imperceptible when taper 193 in. from screen
1868 D	Vumpurthy	"my lights were distinctly seen 3/4 of a mile off"
1870 E	Seville	"charcoal burners' fires in the mountains, some five miles distant were plainly visible"
1880 A	Santa-Lucia	"sky was too bright on account of the contracted diameter of the cone of shade"
1886 BA	Grenada	darkest eclipse since eclipse records have been in vogue
1887 F	Tomsk	... in most houses it was necessary to light candles or lamps
1889 A2	Cape Ledo	"white tents of the American camp, half a mile distant, were distinctly visible."
1900 EB	Virginia Beach	"... The stars did not seem to spring out with the same brilliance"
1914 A	Stromsund	"The darkness was not very great"
1927 B	Yorkshire	"illumination... was very much more than what has been described on some occasions"

open. Thus, in one instance, convolvulus closed while mimosa remained open. Arago then proposed that under controlled conditions the lighting on these plants should be progressively attenuated until that value was reached at which, for a two minute period (equivalent to the duration of totality), the leaves of one closed while the other remained open. He noted that the presence of walls, buildings, etc., in the natural setting made the experiment not worthwhile for the 1842 eclipse but suggested it as a possibility for later eclipses. We are not aware of any later work based on Arago's suggestion. A variant would be to find the equivalent twilight conditions for these plants, but we have not attempted to do this. Additional examples of the effects of eclipses on plants are given in Ranyard. [8]

9. CONCLUSIONS FOR TOTAL SOLAR ECLIPSES

Photometric data which provide good quantitative information on the sky brightness during eclipses are surprisingly few in number. The general characteristics of brightness can, however, be determined from these data. Anecdotal data exist from antiquity onwards from which some information might be thought to be derivable. The most common of these are notations of stars being visible during totality. From the typical brightness derived photometrically, we may predict that third magnitude stars should be visible in the neighborhood of zenith. These are, however, noted only in a small fraction of all cases, and in these cases there seems, on the whole, to be nothing very unusual about the degree of darkness. These notations, therefore, do not seem useful as indicators of sky brightness. Comparisons with moonlight nights found in the anecdotal data seem interesting solely for their psychophysical content, inasmuch as totality brightness is of the order of 10^3 that of full moon. Exotic methods of determining sky brightness based on the behavior of plants or animals may be possible, but to the best of our knowledge have not yet been applied though data which could be used in such an attempt exist. Arago, in 1842, proposed a method by which the leaf closings of different species could be used for photometric purposes but no estimates based on this technique are available. Some estimates of equivalent twilight conditions are available by different methods, and many of these are in reasonable accord with photometric results. Anecdotal data of the visibility of objects, print, or instrument divisions can be used to provide some information on at least dark eclipses. Finally, comparisons are sometimes available which allow for the rank ordering of a small number of eclipses.

We have not attempted to derive the maximum possible information from these data. Nevertheless we tentatively conclude that, for the darker eclipses at least, the darkness is correlated with the solar radiation intensity, and thus presumably with the amount of dust in the atmosphere. The result is reasonable since the umbral sky brightness is due to scattered light which has originated at some distance from the umbra, and will therefore be strongly attenuated by dust along the intervening path. In the period from 1883 to 1918 volcanic eruptions in 1883, 1902, and 1912 produced significant quantities of atmospheric dust and reductions in the solar radiation intensity in the northern hemisphere. Eclipse data are available for the 1880's and will be discussed below. In the interesting period from 1902-1904, however, the two total eclipses are largely or entirely in the southern hemisphere and over water, and no data are available. In 1912 two eclipses occur, one prior and one after the Katmai eruption. The first, however, while almost total, was annular except possibly in Portugal, and no good estimate of totality brightness can be obtained. For the second almost all the observing parties were in Brazil where the eclipse occurred during a torrential rainstorm.

Following the Krakatoa eruptions of 1883 the solar radiation intensity in the northern hemisphere decreased through 1885 and then increased through 1887, with marked variations in the course of each year. The eclipses of 1886 and 1887 occurred close to the minimum radiation intensities for those years, and both are the darkest for the period from 1883-1918. The eclipse of 1885 observed in New Zealand, however, seems to have been of normal brightness even though the northern hemisphere radiation intensity was at its lowest for the entire period. This may be due to a transfer of dust from the southern to the northern hemisphere, or to a buildup in the northern hemisphere from other causes. Fisher[16] in a study of lunar eclipses has noted that eclipses, in which the moon is lit by refracted light from the southern hemisphere, are significantly brighter than those lit by refracted light from the northern hemisphere. He attributes this to the fact that most deserts are in the northern hemisphere and wind blown dust would thus be most prevalent there. In addition, since most land masses are in the northern hemisphere dust-producing mechanisms such as forest fires would be more prevalent in the northern than in the southern hemisphere. The brightness of the 1885 eclipse in the southern hemisphere is consistent with this hypothesis. While it is normally assumed that the 1885 minimum in solar radiation intensity in the northern hemisphere is due to the Krakatoa dust, it appears from the foregoing that we should also allow for the possibility of wind storms or forest fires in the northern hemisphere being at least partially responsible.

10. PARTIAL SOLAR ECLIPSES

As pointed out previously every total solar eclipse includes partial phases. Studies of total eclipses (see Part 1) have shown that until quite close to totality the sky brightness results from what is essentially attenuated sunlight. Nevertheless several measurements have been carried out during partial eclipses. We have not attempted to make a complete survey of such measurements and present here only some few examples of these measurements.

11. TOTAL LUNAR ECLIPSES

Lunar eclipses, while of considerable historical interest and of interest from a cultural point of view, have received little attention from a scientific point of view. Scientific measurements have consisted almost entirely of studies of the darkness of

16. Fisher, W.J. (1924) The brightness of lunar eclipses 1860-1923, Smithsonian Misc. Coll. 76(No. 9).

the moon during the eclipse and deductions about the earth's atmosphere that could be made on the basis of the light curve throughout the eclipse.* In his earlier book, Link (1956) quoted some research indicating ionospheric propagation effects during eclipses. The reality of these, however, seems doubtful in view of the fact that the full moon is about 10^{-6} times as bright as the sun, so that, given the same proportion of ionizing radiation in reflected as in direct sunlight, the effects on the ionosphere might be anticipated to be small. If sufficient ultraviolet light is present, however, to produce effects in the upper atmosphere we might anticipate a change in the 5577 A [OI] intensity in the night airglow during a total solar eclipse. We are aware of only one such measurement, that of Rosenberg and Davis (unpublished), and this shows no change during the eclipse that can be attributed to the eclipse. As part of the same experiment measurements of the continuum near this wavelength were carried out, and these are, as far as we are aware, the only measurements of sky brightness during a total lunar eclipse. The results are included here as Part 5.

*Studies carried out during lunar eclipses have been summarized by Link.[17]

17. Link, F. (1956, 1969) Die Mondfinsternisse Liepzig: Akademische Verlagsgesellschaft, 1956; Eclipse Phenomena in Astronomy, New York: Springer-Verlag, 1969.

Part 1

Photometric Data

28-29 AUG 1886 1886 B
Observ. 10, 306 (1887)
Grenada

Mr. W.H. Pickering made "photometric measurements on the general light during totality" at Granada "which, roughly stated, indicate a brightness equal to one candle at about 29 inches distance."

28-29 AUG 1886 1886 C
Phil. Trans. 180A, 363 (1889)
Hog Island
W. de W. Abney & T.E. Thorpe

Three instruments were taken to Hog Island (12°0'4"N, 61°43'45"W) to measure "the comparative brightness of the corona at different distances from the moon's limb", "the total brightness of the corona, excluding as far as possible the sky effect", and "the brightness of the corona, together with the brightness of the sky in the direction of the sun." At the time of totality the sun's elevation was approximately 19°; the sky was hazy; there were showers at times; and approximately 60 seconds from the calculated end of totality, a cloud covered the sun.

The instrument used to measure the total brightness of the corona, excluding as far as possible the sky, was an integrating box which consisted principally of "a long deal box coated with lampblack, in which a screen with a large grease spot was inserted." A glow lamp was placed at one end of the box and the other end was pointed toward the center of the moon. A hole was provided in the side of the box for observation of the screen. The basic principle of this instrument is described elsewhere by Abney and Festing.[18] The instrument used to measure the brightness of the corona plus sky was "an ordinary Bunsen bar photometer, 60 inches in length, with movable disc, made by Messrs. Alex. Wright and Co." which was altered by replacing the two standard candles with a glow lamp.

The results obtained from the two instruments are presented in Tables 6 and 7.

18. Abney, W. deW. and Festing, (1887) Roy. Soc. Proc. 43

Table 6. Readings on the Integrating Box Reduced to Values of Light Intensity

Voltameter Readings	Value of Light at 1-foot From Screen in Siemens Units*	Approximate Time When Readings Were Made From Beginning of Totality
5.4	0.0197	15
6.2	0.0122	30
5.9	0.0142	45
7.0	0.0075	60
6.8	0.0085	75
7.1	0.0070	90
7.3	0.0065	105
7.3	0.0065	120
7.7	0.0054	135
7.8	0.0051	150
8.3	0.0045	165
8.8	0.0040	180
8.9	0.0035	195
9.3	0.0030	210
9.4	0.0027	215
9.4	0.0027	220

*A siemens unit is approximately 0.8 of a standard candle.

Table 7. Readings on the Bar Photometer Reduced to Values of Light Intensity

Distance of Lamp From Screen in Inches	Equivalent Value in Siemens Unit* at 1-foot	Approximate Time of Reading
33.5	0.0160	50
34.4	0.0152	70
36.2	0.0137	90
39.1	0.0118	110
39.6	0.0115	130
44.1	0.0093	150
46.4	0.0084	170
47.8	0.0079	190
48.0	0.0078	210
47.8	0.0079	220
48.5	0.0077	230

*A siemens unit is approximately 0.8 of a standard candle.

17 APR 1912 1912 A
Comptes Rendus 154, 1141-1142 (1912)
48°49'N. Lat. 0°21'W. Long.
R. Jouaust & P. de la Gorge

An attempt was made to "bring into relief the lighting produced by the sun on a horizontal plane at various times of the eclipse of April 17" at an altitude of 130 meters at 0°21' Long. West and 48°49' Lat. North.

The photometer Mascart of the Central Laboratory of Electricity was used to make the determinations, and an electric lamp fed by a portable battery was used as reference.

The results are shown in Table 8, in which the hours are expressed in legal time and the lightings in lux.

Table 8. Lightings During the Eclipse of 17 April 1912

Hours	Lighting (lux)	Hours	Lighting (lux)
10h 42m 50,5	50000	12h 7m 11,5	960
55. 15,5	50000	7. 33,5	820
11. 0. 50,5	45000	8. 5,5	780
14. 13,5	40000	8. 30,5	520
20. 40,5	38000	8. 50,5	380
29. 21,5	35000	9. 55,5	16
38. 50,5	28000	11. 15,5	480
42. 54,5	25000	12. 19,5	790
46. 51,5	22000	12. 50,5	1090
50. 7,5	17000	14. 25,5	1740
53. 32,5	14000	15. 23,5	2100
56. 25,5	10000	16. 48,5	2850
59. 0,0	7400	18. 28,5	3480
12. 0. 8,5	6200	20. 21,5	7000
0. 43,5	5700	22. 8,5	8000
1. 27,5	4800	24. 35,5	10700
2. 0,0	4100	26. 40,5	12300
2. 22,5	3700	29. 2,5	13500
2. 40,5	3300	31. 52,5	25000
3. 14,5	2700	35. 36,5	29500
3. 44,5	1900	40. 17,0	35000
4. 27,5	1420	50. 49,0	50000
5. 26,5	1200	1. 8. 54,0	50000
6. 30,5	1040	17. 24,0	50000

8 JUN 1918 1918 A
Astrophys. Jour. 49, 137 (1919)
Rock Springs, Wyoming
J. Kunz & J. Stebbins

Observations were made at Rock Springs, Wyoming, altitude 6500 ft., "to secure accurate measures of the light of the corona as it affects a photo-electric cell." The procedures to be employed were to "expose a photo-electric cell directly to the corona at the time of totality, and compare the galvanometer deflection then obtained with the deflection caused by standard lights at known distances before and after the eclipse," and to "compare the corona with a definite area of the sky during the eclipse" by pointing the cell first at the sun and then to the sky 8° north of the sun and turning the instrument back and forth from the sun to the sky throughout the eclipse. During totality the sky was generally cloudy, but the field 8° north of the sun remained clear.

Two photo-electric cells mounted so as to give a "double barrel arrangement" were used. Each was 40 mm in diameter and "was placed in a box with a 25 mm circular opening, which was central at the end of a tube 100 mm in diameter and about 122 cm long." A diaphragm of 89 mm in aperture was placed at the upper end of the tube 127 cm from the cell. Thus, any point on the cell "was illuminated by a circle of sky with radius = 2°0." The clear field of the apparatus was 3° in diameter.

The results are presented in Table 9. It was calculated that the sky intensity was reduced 6100-fold by the moon's shadow.

Table 9. Observations During Totality

Time in Counts From Beginning of Eclipse (100 counts/ 95 sec)	Exposure To	Galvanometer Reading (div)	Deflection (div)	Unit = N_1* at 1 Meter	
				Corona + Sky	Sky
0 ...	Dark	90	0.0	.....	.....
10 ...	Corona + Sky	123	33.0	0.682	0.072
20 ...	Sky	93	3.1	.....	.....
30 ...	Corona + Sky	125	35.1	0.723	0.072
40 ...	Sky	93	3.1	.....	.....
50 ...	Corona + Sky	124	34.2	0.705	0.072
60 ...	Dark	89.8	0.0	.....	.....
70 ...	Sky	92.8	3.1	.....	.....
80 ...	Corona + Sky	126	36.3	0.746	0.077
90 ...	Sky	93.2	3.6	.....	.....
100 ...	Dark	89.5	0.0	.....	.....

*N_1 = 0.93 candle power as measured by a potassium cell.

8 JUN 1918 1918 B

Smithsoniam Misc. Collections 69, 1 (1919)
Lakin, Kansas
L. B. Aldrich

Two of the primary objectives of the eclipse expedition to Lakin, Kansas (37°53'N, 101°17'W, and 3,000 ft. height) were to measure sky brightness and to measure the total radiation from the sun and the sky. Observations were made on the day of the eclipse from about one o'clock local summer time until after ten o'clock at night, although no observations were recorded during totality. Not so frequent observations were made for comparison in a considerably clearer sky on the day following the eclipse.

The instrument used was Pyranometer A. P. O. No. 5 (see [19]) partially rebuilt by inserting a new thermopile, consisting of four tellurium-platinum thermo-elements, beneath the blackened manganin strip. Further modifications included increasing the size of the sun shade "so as to shade from direct sun rays the whole copper disk surrounding the absorbing strip" and raising the shade to about 35 cm from the strip "so as not to intercept too large a sky area." During the eclipse the pyranometer was "mounted outside on a pier about 6 meters west of the shelter at an altitude of 1.5 meters above the ground" so that "the absorbing strip was horizontal and was exposed to almost a complete hemisphere of sky, only a small portion of the sky low in the east being cut off by the barn."

Tables 10 and 11 summarize the observations of June 8 and June 9 with columns 2 and 3 giving "the calories of radiant energy reaching a square centimeter of horizontal surface per minute from the whole sky (the sun being shaded), and from the total sky and sun respectively." Figures 2 and 3 are a graphic representation of the results with Figure 2 showing sky radiation versus hour angle and Figure 3 showing sun and sky radiation versus hour angle. It was noted that "the total brightness of the sky was less than that of the twilight one hour after sunset of the same day."

19. Smithsonian (1971) Misc. Coll. 66:7.

Table 10. 8 June 1918

Hour Angle (west)	Sky Brightness	Sky and Sun	Remarks
h. m. s.	(Calories)	(Calories)	
0 14 40	.349	....	Wind S. E.
16 50	....	0.556	Clouds breaking, especially
32 25	.388	....	in west. Sun shines inter-
34 25	....	1.597	mittently.
40 05	.378	....	
41 25	....	1.540	
44 15	.381	....	
45 05	....	1.556	
1 12 40	.217	....	
13 15	....	1.300	
15 45	.232	....	Cumulus clouds disappearing.
35 40	.250	....	Strati-cirri developing over
36 45	....	1.310	whole sky.
40 25	.235	....	
41 25	....	1.333	
46 05	.253	....	
47 25	....	1.352	
2 13 45	.214	....	
15 25	....	1.237	
17 30	.218	....	
44 20	.250	....	
46 20	....	1.178	
3 14 10	.203	....	
16 35	....	1.048	
17 30	.203	....	
27 50	.215	....	
29 40	....	.972	Strati-cirri over whole sky.
30 55	.214	....	Cumuli low in west and
41 55	.195	....	east.
44 05	....	.784	
46 40	.177	....	First contact at $3^h35^m52^s$.
54 55	.154	....	
56 50	....	.682	
58 0	.136	....	
4 06 55	.102	....	
08 20	....	.502	
08 55	.097	....	
12 40	.0792	....	
13 55	....	.397	
15 10	.0742	....	
21 55	.0514	....	
23 10	....	.245	
23 45	.0471	....	
28 0	.0340	....	
28 50	....	.163	
29 35	.302	....	
33 45	.0188	....	
34 10	....	.0864	
34 45	.0181	....	
35 10	.0140	....	
40 25	.0031	....	

Table 10 (Contd.). 8 June 1918

Hour Angle (west)	Sky Brightness	Sky and Sun	Remarks
h. m. s.	(Calories)	(Calories)	
4 40 55	....	.0167	
41 10	.0017	....	
			Eclipse total from $4^h43^m19^s$ to $4^h44^m41^s$.
44 55	.0006	....	
45 25	....	.0031	
4 45 50	.0019	....	
49 25	.0088	....	
49 55	....	.0305	
50 30	.0119	....	
55 10	.0283	....	
55 50	....	.0871	
56 10	.0333	....	
59 25	.0493	....	
59 55	....	.120	
5 0 25	.0528	....	Strati-cirri continue.
04 50	.0721	....	
05 25	....	.161	
05 55	.0735	....	
13 20	.1028	....	
13 45	....	.268	
15 25	.1063	....	
30 55	.145	....	
31 30	....	.324	
32 05	.144	....	
43 40	.148	....	
44 10	....	.298	
44 55	.1485	....	Fourth contact at $5^h45^m49^s$.
6 13 05	.1080	....	
15 55	....	.131	
15 55	.1022	....	Thick strati-cirri around horizon (which obscured sun soon after 6.44).
42 40	.0559	....	
43 40	....	.0554	
44 40	.0512	....	Also streaked over whole sky. Very little wind.
7 20 25	.00371		Sun below horizon.
21 10	.00295		Sunset 7^h17^m.
22 55	.00231		
56 30	.00193		
8 34 30	0		

Table 11. 9 June 1918

Hour Angle (west)	Sky Brightness	Sky and Sun	Remarks
h. m. s.	(Calories)	(Calories)	
0 23 0	.1378	....	Sky clear except of some
24 50	....	1.587	cumuli around horizon.
27 40	.1338	....	Little wind.
48 45	.1245	....	
49 35	....	1.462	
50 35	.1278	....	
1 21 25	.1126	....	
22 10	....	1.533	
23 10	.1142	....	Cumuli increasing somewhat.
52 25	.1262	....	
52 55	....	1.349	
53 35	.1262	....	
2 10 0	.1228	....	
21 35	....	1.223	
22 25	.1145	....	Wind increasing.
3 14 15	.1109	....	
14 45	....	1.033	
15 45	.1178	....	
45 30	.1145	....	
46 0	....	0.909	
46 45	.1042	....	
4 23 15	.0924	....	
24 0	....	.712	
24 45	.0952	....	
36 30	.0895	....	
39 05	....	.642	
39 55	.0905	....	
5 57 45	.0855	....	Considerable cirri over
58 30	....	.311	whole sky.
59 25	.0885	....	

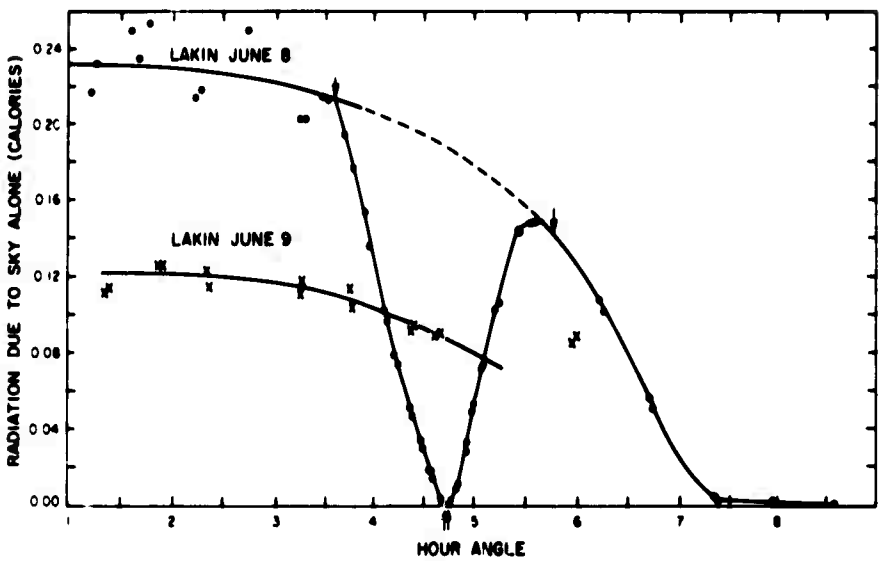


Figure 2. Radiation Due to Sky Alone Versus Hour Angle at Lakin, Kansas, 8 and 9 June 1918

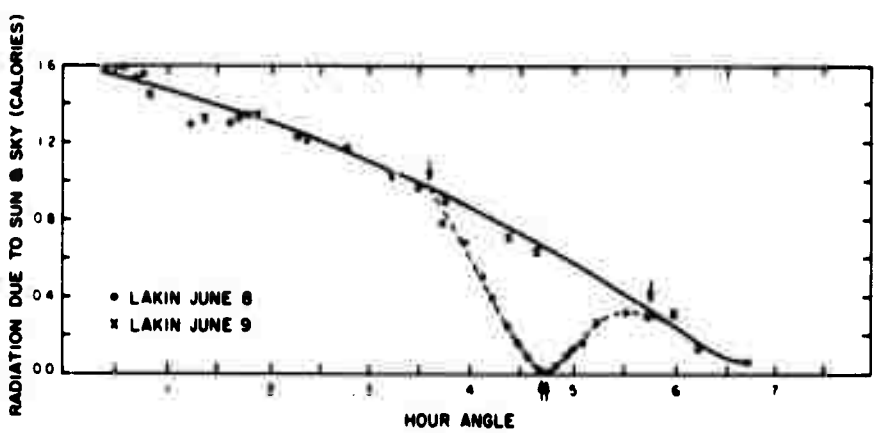


Figure 3. Radiation Due to Sun and Sky Versus Hour Angle at Lakin, Kansas, 8 and 9 June 1918

21 SEP 1922 1922 C
"Eclipses of the Sun" Columbia Univ. Press p. 397 398 (1935)
Australia
S. A. Mitchell

"At the Australian eclipse of 1922, Ross directed a camera, from which the lenses had been removed, toward the south celestial pole and exposed a photographic plate during totality. Other plates from the same box were exposed on the evening of the same day for equal intervals of time at 6:14, 6:17, 6:20, 6:23 and 6:26 by the clock. The central portions of the plate were cut out and all six plates were developed together. The plates showed a regular gradation. It was found that the illumination at the south celestial pole corresponded with that when the sun's center was $97^{\circ}29'$ from the zenith."

21 SEP 1922 1922 D
Astrophys. Jour. 60, 273 (1924)
Goodiwindi, Queensland
G. H. Briggs

Part of the work of the eclipse expedition to Goodiwindi, Queensland was to measure the total intensity of the light of the corona "with two photo-electric cells by a method similar to that used by Kunz and Stebbins[20] in 1918."

The two photo-electric cells used had active surfaces of potassium and contained helium. They were mounted in boxes similar to those used by Kunz and Stebbins with any point of cell 1 being illuminated by a circle of diameter $5^{\circ}53$, and with cell 1 having a circular clear field of $3^{\circ}86$. Cell 2 had corresponding circles slightly greater than cell 1. The two tubes were mounted independently with the tube for cell 1 being set on an alt-azimuth mounting which allowed the cell to be pointed at the position of midtotality or to be rotated 10° to the east "to obtain readings of the sky alone", and the tube for cell 2 being mounted to allow rotation "a similar distance toward the zenith about a horizontal axis, for readings of the sky." Two candle-power 6-volt motor-car lamps were used as standards. The fluctuations of the lamps were such that "the accuracy of the results is probably not more than 10 or 15 per cent."

Tables 12 and 13 give the observational and calculated results with column 1 giving "the approximate times from second contact at which the readings were made", columns 3 and 4 giving "the readings as observed and the corresponding deflection, allowance being made for the zero shift", column 5 giving "the deflections when corrected by the calibration curve of the cell," and the remaining columns giving "the intensities of the corona and sky in Hefner units."

20. Kunz, J., and Stebbins, J. (1919) Astrophys. J. 49:137.

Table 12. Cell 1

Time in Seconds From 2nd Contact	Exposure to	Galvanometer Reading (cm)	Deflection (cm)	Corrected Deflection (cm)	Brightness (Hefner Candle-Meter) Corona + Sky	Brightness (Hefner Candle-Meter) Sky
	Dark	10.00	0.00	0.00		
25	Corona + Sky	13.10	3.11	3.11	0.443	
45	Same with H filter	10.82	0.85	0.78	0.111	
65	Same with B filter	10.18	0.24	0.22	0.031	
85	Sky	10.45	0.46	0.42		0.060
105	Corona + Sky	12.12	2.21	2.14	0.305	
125	Sky	10.57	0.67	0.63		0.090
145	Corona + Sky	12.45	2.57	2.52	0.360	
165	Sky	10.10	0.23	0.21		0.030
185	Corona + Sky	12.49	2.64	2.59	0.370	
205	Sky	10.45	0.61	0.56		0.080
225	Dark	9.84	0.00	0.00		
Mean						0.077

Table 13. Cell 2

Time in Seconds From 2nd Contact	Exposure to	Galvanometer Reading (cm)	Deflection (cm)	Corrected Deflection (cm)	Brightness (Hefner Candle-Meter) Corona + Sky	Brightness (Hefner Candle-Meter) Sky
10	Dark	13.3	0.00			
30	Corona + Sky	15.55	2.25	2.25	0.420	
45	Sky	13.92	0.60	0.55		0.105
60	Corona + Sky	15.30	1.90	1.88	0.347	
75	Sky	13.90	0.45	0.41		0.081
90	Corona + Sky	15.35	1.85	1.83	0.339	
110	Dark	13.50	0.00			
130	Corona + Sky	15.18	1.66	1.61	0.304	
145	Sky	13.85	0.30	0.28		0.051
175	Corona + Sky	15.47	1.85	1.83	0.339	
190	Sky	14.15	0.45	0.41		0.081
205	Corona + Sky	15.55	1.85	1.83	0.339	
225	Dark.	13.75	0.00			
Mean						0.08

Trans. Ill. Eng. Soc. 20, 5 5 (1925)
N. Y., Ontario, & Conn.

During the eclipse, fourteen expeditions located in New York, Ontario, and Connecticut took photometric measurements with various instruments, under various weather conditions, and with various results. The results for total horizontal illumination weighted as to the clearness of sky are given in Figure 4, the minimum illumination being about 0.24 ft. candle.

Eleven observers from 3 of the expedition locations met on the roof of a building in New York City on January 26th, and each independently estimated the time at which he thought "the visibility conditions were equivalent to those which prevailed during totality." The range of estimates was from 5:28 to 5:34 P. M., with one estimate of 5:20 P. M. being disregarded. The estimates centered around the hour of 5:30. "The foot-candles from 5:28 to 5:34 ranged from 0.48 to 0.13," and was approximately 0.3 at about 5:30 P. M.

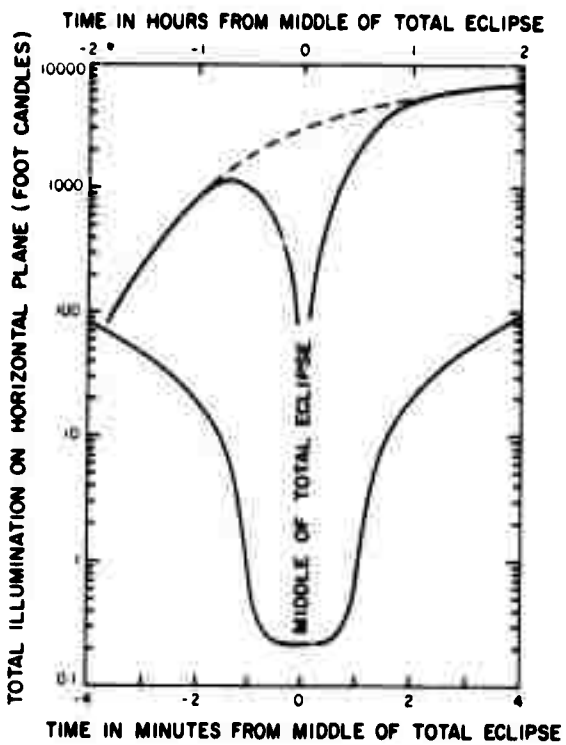


Figure 4. Total Horizontal Illumination From Various Locations Weighted as to Clearness of Sky at the Eclipse of 24 January 1925

14 JAN 1926 1926 B
Astrophys. Jour. 66, 65 (1927)
Benkoelen, Sumatra
H. T. Stetson et al.

Among the objectives of the Harvard expedition to Benkoelen, Sumatra was "photometric measurements with a visual illuminometer of the total light of the corona and a determination of the light-curve during minimum." A Macbeth illuminometer manufactured by Leeds and Northrup Company fitted with an elbow diffusing screen was used to obtain the measurements which were taken through a thin veil of cirrus cloud. The diffusing screen "received light of practically the entire sky during totality." The instrument was "carefully calibrated before and after trans-shipment."

A photographic photometer described elsewhere by King[21] was also employed at the eclipse. Four plates were exposed to the corona and sky with one exposure of 4 seconds and one exposure of 2 seconds on each plate. Two additional plates, Plates V and VI, were exposed to the sky 8° east of the sun. The aperture employed for Plates I, IV and V covered 3° and for Plates II, III and VI, 6° of the sky. Two types of plates were used the first being ordinary or "blue" plate and the second being isochromatic or "yellow" plate. A Hefner lamp and amyl acetate (c.p.) were used "for imposing the standard exposures for purpose of comparison."

The light-curve plotted logarithmically from the illuminometer observations is shown in Figure 5, and gives "the minimum intensity at maximum eclipse as 0.138 foot candles." Figure 6 gives an enlargement of "the form of the light-curve near minimum." Table 14 gives the results of all the photographic plates of the corona and Table 15 gives the results of the photographic brightness of the sky.

Table 14. Brightness of Coronal Light. Magnitude Differences Are Hefner Lamp

Plate No.	Aperture	Blue Mag. Diff.			Yellow Mag. Diff.		
		4 sec	2 sec	Mean	4 sec	2 sec	Mean
I	3°	-0.70	-0.74	-0.72	+1.90	+1.90	+1.90
II	6°	(.19)	.86		1.32	1.62	1.47
III	6°	.49	.44	.48	1.63	2.14	1.89
IV	3°	-0.68		-0.68	+1.89		+1.89
Mean for 3°			0.70			+1.89	
Mag. of Hefner		Ptg.	10.68		Ptv	-13.89	
Mag. of Corona 3° circle			11.38			-12.00	Color Index +0.62
Mean for 6°			0.67			+1.76	
Mag. of Hefner			10.68			-13.89	
Mag. of Corona 6° circle			11.35			12.13	.78

Ptg. = photographic magnitude Ptv = photovisual magnitude

21. King, E.S. (1926) Harvard College Circular No. 286.

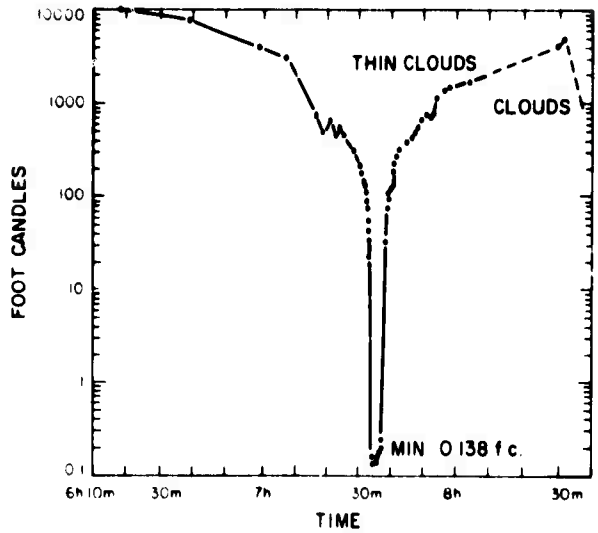


Figure 5. Total Normal Illumination During Solar Eclipse of 14 January 1926

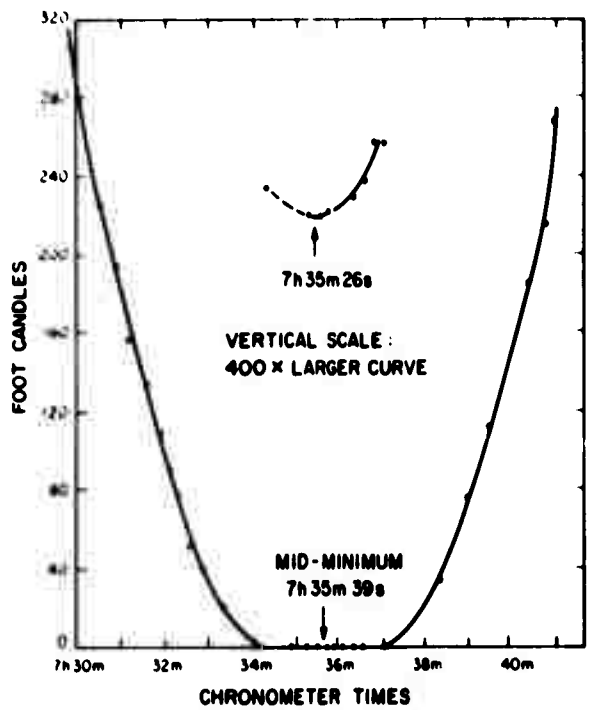


Figure 6. Illumination Curve Through Totality of Solar Eclipse of 14 January 1926

Table 15. Photographic Brightness of Sky

Plate No.	Aperture	Mag. Blue (Ptg.)
V	3^{o}	-8.09
VI	6^{o}	-9.92

29 JUNE 1927 1927 E
Nature 120, 84 (1927)
Criccieth, Wales

Mr. A. Taylor and his colleagues made measurements at Criccieth, Wales of "the intensity of daylight" during the eclipse with a Trotter photometer "set up to face that part of the clouds which hid the sun." Figure 7 gives the results of the observations with the minimum recorded intensity being 0.05 foot-candle.

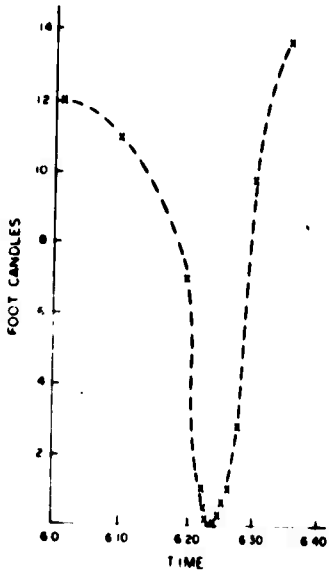


Figure 7. Illumination Curve of Solar Eclipse of 29 June 1927

29 JUN 1927 1927 F
Nature 120, 83 (1927)
Southport, England

Mr. A.S.E. Ackermann went to Southport, England to "measure the illumination received by a horizontal surface exposed to the hemisphere of the sky during the whole period of the eclipse." A white test surface was placed 6 inches above the ground and except for the obstruction of the observer's crouched body, was exposed to the hemisphere of the sky. Readings were taken from the surface by means of "a daylight photometer (a lumeter)."

During the eclipse the sky was hazy with variations of thickness noticeable at the beginning and end of the readings. The results, allowing for the light obstructed by the crouched body, are plotted in Figure 8.

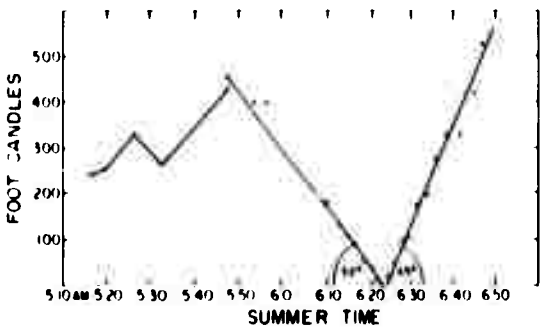


Figure 8. Illumination Due to the Hemisphere of Sky During the Solar Eclipse of 29 June 1927

29 JUN 1927 1927 G
The Ill. Eng. 21, 198 (1928)
Leyburn, England

One of the primary objectives of the eclipse expedition to Leyburn, England ($54^{o}19'N$, $1^{o}50'W$) was "to determine the variation of the illumination of a horizontal surface due to the light received from a complete hemisphere of sky."

The apparatus used in the measurements was "an internally whitened sphere, four inches in diameter, having a circular opening of one inch diameter" on whose side a portable photometer of the Macbeth pattern was mounted for sighting "through a small hole in the sphere on to a portion of the inside wall opposite." The sphere was "carefully adjusted, so that the edge of the aperture lay exactly in a horizontal plane." A disc of calculated diameter was placed 10 feet from the sphere in such a manner as to "cut off the light from the sun and the corona."

The disc shaded a patch of sky of about 3^{0} diameter. The sphere was positioned so the observer's head was "completely below the level of the aperture in the sphere." The Macbeth illuminometer used was carefully calibrated both before and after the expedition with the estimated accuracy of individual readings being "about 5 percent." A neutral light filter was used.

Observations were made in spite of the fact that the sky was heavily overcast. The results can be seen in Figure 9 and show a minimum value of 0.18 foot-candle.

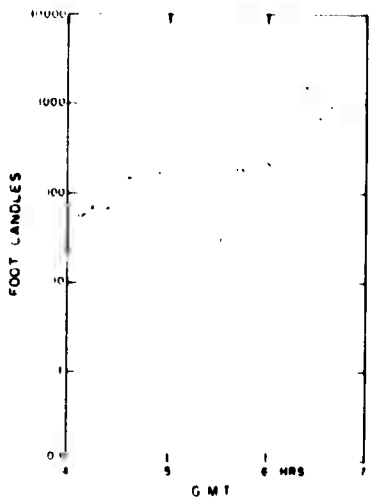


Figure 9. Variation of Horizon Illumination Due to Complete Sky During the Solar Eclipse of 29 June 1927

9 MAY 1929 1929 A
Astrophys. Jour. 74, 122 (1931)
Alor Star, Malaya
H. T. Stetson et al.

During the eclipse, the Harvard expedition to Alor Star, Malaya took measurements of the combined illumination of the corona and a considerable area of the sky in which "a veil of thin cirrus prevailed in the region of the sun."

The Macbeth illuminometer used was the same one used in Sumatra in 1926 and previously described by Stetson et al,[22] modified so that "all the required absorbing screens were arranged in sequence on two separate slides that could be manipulated by touch." The instrument was mounted on "two supporting Y's

22. Stetson, H. T., et al (1927) Astrophys. J. 66:65.

with the diffusing screen so oriented as to be at right angles to the line of the sun during totality." The instrument was calibrated both before and after the eclipse observations by means of "a standard lamp specially prepared for the purpose."

Table 16 gives "a summary of selected readings at convenient intervals," while Figures 10 and 11 give "the light curve resulting from all the measures." The minimum illumination at midtotality was found to be 0.15 foot-candles.

Table 16. Summary of Measures With the Illuminometer at Alor Star, Malaya, 9 May 1929

Watch Time Hr	Min	Sec	Foot Candles
5.....	32	15	6,839
	19	0	4,251
	34	22	3,312
	50	1	3,084
6.....	1	10	2,870
	5	17	3,245
	8	15	2,280
	11	7	1,985
	18	5	1,018
	22	37	686
	25	19	575
	28	43	355
	29	54	263
	30	53	203
	31	19	169
	32	14	101
	33	8	53.4
	34	4	20.0
	34	14	13.5
	34	37	4.1
	34	48	1.6
	35	15	0.391
	35	29	0.311
	35	38	0.276
	35	48	0.288
	44	57	226
	45	49	263
	46	45	361
	47	4	357
	48	49	501
	50	5	542
	51	52	706
	54	21	862

Watch Time Hr	Min	Sec	Foot Candles
6.....	36	41	0.166
	36	48	0.180
	36	55	0.160
	37	7	0.180
	37	15	0.191
	37	23	0.180
	37	31	0.203
	37	39	0.197
	37	45	0.185
	37	51	0.203
	37	58	0.203
	38	5	0.203
	38	22	0.246
	38	27	0.234
	38	35	0.272
	38	52	0.391
	39	10	0.529
	39	33	0.874
	39	53	1.84
	40	8	5.20
	40	34	13.5
	40	44	21.0
	41	36	51.7
	42	42	113
	44	5	172
	44	27	201
	55	54	977
7.....	0	17	1,190
	3	35	1,453
	7	0	2,065
	16	36	3,554
	26	41	5,216
	35	26	6,973

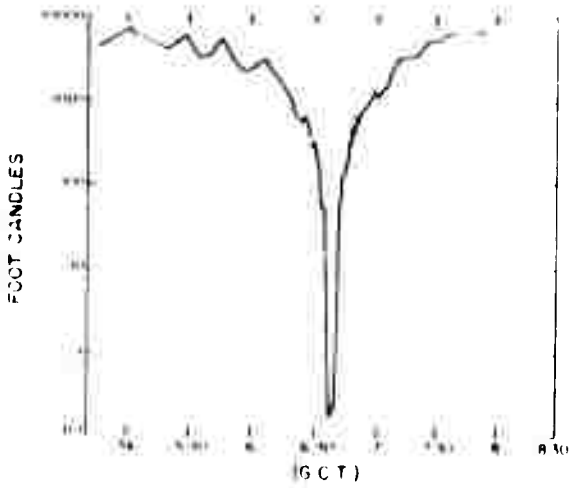


Figure 10. Illumination of Corona Plus Considerable Area of Sky During Eclipse of 9 May 1929

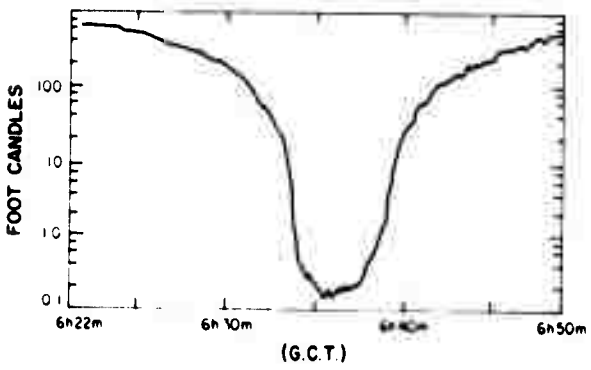


Figure 11. Midpart of Light-Curve of 9 May 1929

21 OCT 1930 1930 A

Astrophys. Jour. 74, 122 (1931)
Niuafou
H. T. Stetson et al.

The eclipse expedition of the United States Naval Observatory to Niuafou used the same instrument and the same procedures previously described in the 9 May 1929 Harvard expedition to Alor Star, Malaya. On this occasion there was a considerable amount of haze and cirrus cloud during totality.

Table 17 gives the times, readings, and tabulation of equivalent foot-candles, and Figures 12 and 13 give the resulting light-curve. The value for minimum intensity was found to be 0.378 foot-candles.

Table 17. Illuminometer Readings and Reductions to Foot Candles Niuafou Eclipse, 21 October 1930 (Watch 33.2 sec fast on G.C.T.)

Watch Time			Scale	Filters		Foot Candles
Hr	Min	Sec		A	B	
19.....	40	3	4.35	4	1	5,830
	45	3	7.55	.....	.....	10,100
	50	3	3.70	.....	.....	4,960
	55	2	5.91	.....	.....	7,910
20.....	0	2	5.09	.....	.....	6,820
	5	3	3.71	.....	.....	4,970
	10	2	2.81	.....	.....	3,760
	15	2	2.43	.....	.....	3,260
	20	2	1.51	.....	.....	2,020
	25	2	1.81	.....	.....	2,430
	30	2	1.58	.....	.....	2,120
	35	2	20.5	4	2	1,670
	40	2	17.0	.....	.....	1,400
	41	1	16.4	.....	.....	1,350
	42	2	11.8	.....	.....	969
	43	1	8.50	.....	.....	698
	44	3	10.3	.....	.....	846
	45	2	8.00	.....	.....	657
	46	3	6.83	.....	.....	561
	47	2	4.05	.....	.....	332
	48	2	3.78	.....	.....	311
	49	2	2.44	.....	.....	201
	50	3	9.20	4	3	101
	50	32	6.21	.....	.....	68.3
	51	0	2.13	.....	.....	23.4
	51	19	6.43	4	4	6.43
	51	40	4.65	3	4	0.535
	51	49	3.80	.....	.....	0.437
	51	59	3.29	.....	.....	0.378
	52	9	3.71	.....	.....	0.427
	52	21	3.80	.....	.....	0.436
	52	30	3.30	.....	.....	0.379
	52	38	3.80	.....	.....	0.436
	52	49	3.90	.....	.....	0.448
	53	9	4.60	.....	.....	0.528
	53	27	7.00	4	4	7.00
20.....	53	51	2.81	4	3	30.9
	54	5	5.00	.....	.....	55.0
	54	18	6.80	.....	.....	74.8
	54	33	7.50	.....	.....	82.5
	54	46	11.0	.....	.....	121
	55	4	1.61	4	2	132
	55	26	2.10	.....	.....	172
	55	46	2.60	.....	.....	213

Table 17 (Contd.). Illuminometer Readings and Reductions to Foot Candles Niuafou Eclipse, 21 October 1930 (Watch 33.2 sec fast on G.C.T.)

Watch Time Hr	Min	Sec	Scale	Filters A	Filters B	Foot Candles
20.....	56	2	2.65	.....	.....	217
	56	33	3.61	.....	.....	297
	57	1	3.14	.....	.....	257
	57	32	4.80	.....	.....	394
	58	2	5.10	.....	.....	426
	59	6	7.00	.....	.....	575
21.....	0	3	8.90	.....	.....	731
	1	2	9.50	.....	.....	780
	2	2	10.1	.....	.....	829
	3	2	13.5	.....	.....	1,110
	4	3	16.5	.....	.....	1,350
	5	3	14.5	.....	.....	1,190
	10	1	1.61	4	1	2,150
	15	2	1.63	.....	.....	2,180
	20	3	1.70	.....	.....	2,280
	25	12	1.62	.....	.....	2,170
	30	3	2.15	.....	.....	2,880
	35	4	2.94	.....	.....	3,940
	40	1	3.80	.....	.....	5,080
	45	13	3.69	.....	.....	4,930
	50	2	3.75	.....	.....	5,020
	55	2	5.30	.....	.....	7,100
22.....	0	3	7.25	.....	.....	9,700
	5	1	7.80	.....	.....	10,400
	10	3	8.20	.....	.....	11,000
	15	1	7.60	.....	.....	10,200

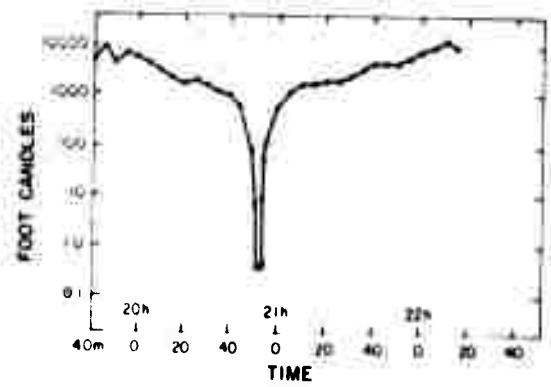


Figure 12. Total Normal Illumination During Solar Eclipse of 21 October 1930

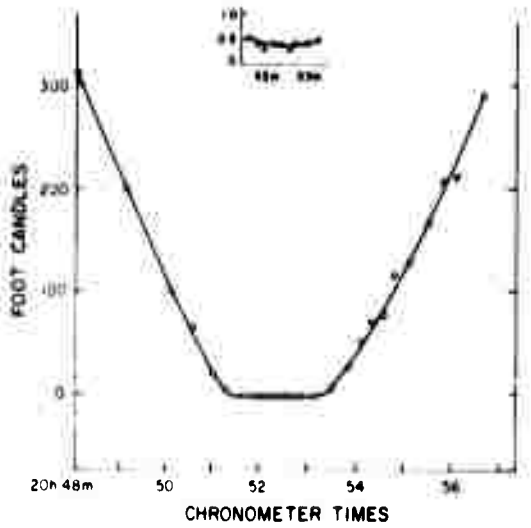


Figure 13. Midpart of Light-Curve Through Totality 21 October 1930

31 AUG 1932 1932 A
J.O.S.A. 23, 234 (1933)
Lancaster, New Hampshire
C. H. Sharp et al.

An expedition was sent from the Electrical Testing Laboratories of New York to Lancaster, New Hampshire "to supplement the work in the photometry of eclipse phenomena which it had done through three expeditions at the time of the 1925 eclipse."

To measure the brightness of the sky, a Macbeth illuminometer "equipped with a lens system adapting it to read the brightness of a patch of the sky slightly less than one degree in diameter" was mounted on a tripod "equipped with worm-screw adjustments so that it could be quickly and accurately aimed in any direction." A specially designed photometer "was fitted with a compensating test plate which gives a good accuracy of integration of the light over an entire hemisphere in accordance with the theoretical cosine law," and was mounted on a heavy tripod for measuring horizontal illumination. Another specially designed optical photometer was used for the measurement of the direct light of the sun and the corona. The three photometers were carefully calibrated and intercomparisons made.

In spite of the fact that clouds rendered the corona invisible, measurements of horizontal illumination were made with Figure 14 giving the results. Table 18 gives the measurements of sky brightness which were made.

Table 18. Sky Brightness

Time	Location	Milli-lamberts
3:26:56	Direction of corona	0.79
	At zenith	0.9
	At an elevation of 30° north	0.4
	At an elevation of 30° east	0.27
	At an elevation of 30° south	0.41
	At an elevation of 30° west	9.0
	At an elevation of 30° west	1.42
	Direction of corona	0.48
3:28	Horizon east	0.53
	Horizon north	6.3
	Horizon west	6.3
	Horizon south	10.7
	Clouds west horizon	1.7
	Clouds north horizon	1.9
	Clouds east horizon	1.2
	Clouds south horizon	1.1

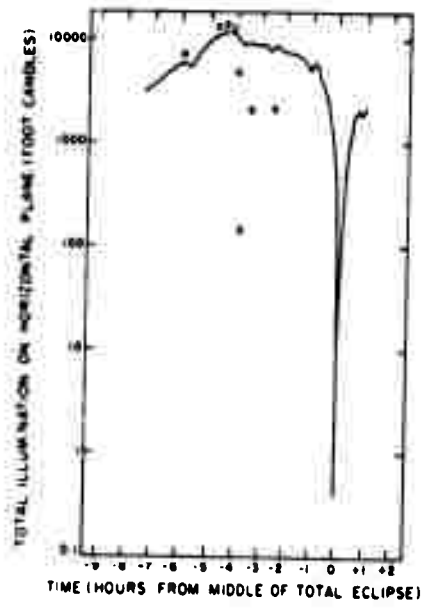


Figure 14. Horizontal Illumination Throughout the Day and Normal Illumination From the Sun 31 August 1932: Curves, horizontal illumination; circle-dots, normal illumination from the sun

19 JUN 1936 & 21 SEPT 1941 — 1936 B & 1941 A

N. N. Sytinskaia, translated from Russian by the American Meteorological Society. AFCRL Translation T-R-655 (1967)

Bartat & Alma Ata, Russia

Observations to determine "the sources of the luminance of the sky and the illumination of the landscape during the total phase of a solar eclipse" were made "during the eclipse of 1936 in the village of Bartat in the Krasnoyarsk district." Weather conditions at the time of the observations were "so unfavorable" that the validity of the measurements was questionable. To test the results of the 1936 eclipse, an expedition journeyed to Alma Ata where "absolute measurements of the luminance of the sky were performed photographically" during the eclipse of 1941 under a "completely cloudless" sky.

The observations at Alma Ata were secured by means of two cameras without objectives which were "directed toward the sky at the sun's elevation, at a distance 10° to its right and left." Photometric processing of the "isochrom" plates showed that "near the sun the sky had a luminance of 2.1×10^{-4} stilbs." Observations

were also made "with the same equipment and at the same height of the sun in the absence of an eclipse" for comparison.

Table 19 gives the results of both the 1936 and the 1941 observations.

Table 19. 1936 and 1941 Eclipse Results

Date of Eclipse	Duration of Total Phase in sec	Method of Measurement	Position and State of Observed Point of Sky	Ratio of Lum. of Sky During Eclipse to Sky w/o Eclipse	Ratio of Light of Corona to Light of Sun	Fraction of Light of Corona to Light of Sun
1936	150	Visual	Clear, disk of moon	5.0×10^{-4}	3.8×10^{-7}	0.76×10^{-3}
	150	Photographic	Clear, mean luminance of sky	2.6×10^{-4}	3.8×10^{-7}	1.4×10^{-3}
	150	Same	Clear, mean luminance of sky	1.2×10^{-4}	3.8×10^{-7}	3.2×10^{-3}
	150	Visual	Cloudy, zenith	1.8×10^{-4}	3.8×10^{-7}	2.1×10^{-3}
1941	120	Same	Clear, 10° from sun	5.7×10^{-4}	4.6×10^{-7}	0.79×10^{-3}
	120	Photographic	Same	6.8×10^{-4}	5.2×10^{-7}	0.78×10^{-3}
	120	Same	Clear, zenith	5.7×10^{-4}	5.2×10^{-7}	0.90×10^{-3}

8 JUN 1937 1937 A
Nat. Geog. Soc. Solar Ecl. Ser. #1, p. 10 (1939)
Canton Island
F.K. Richtmyer

The illumination on a horizontal plane due to corona plus 180° of sky was measured at Canton Island. Although the sky was cloudy, the sun was seen throughout totality.

To secure the illumination produced by the corona plus 180° of the sky, "a 6-cell target of a Weston illuminometer was connected to a sensitivie microammeter." Precision calibration of instruments to secure absolute values of illumination was not attempted.

Figure 15, curve C "gives the illumination on a horizontal plane due to corona plus 180° of sky" with the value at midtotality being .115 f.c.. It was also found that the normal illumination due to corona plus 5° of sky background was 0.019 f.c.

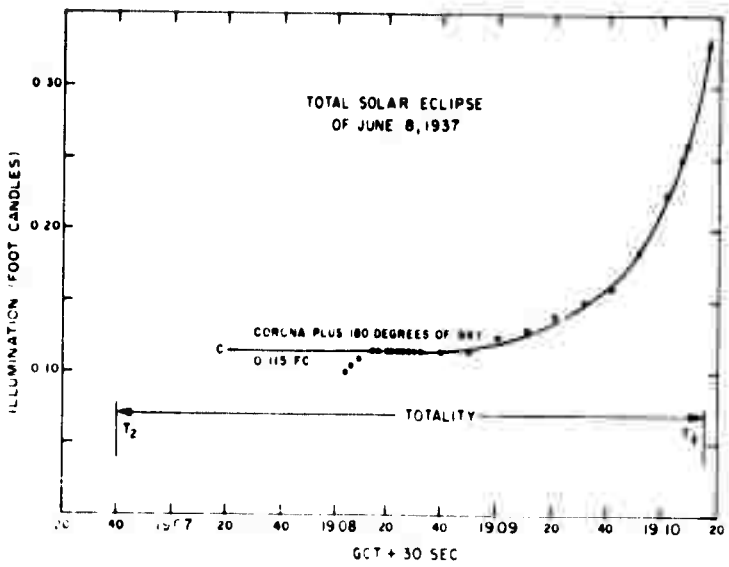


Figure 15. Illumination on a Horizontal Plane Due to Corona Plus 180° of Sky During Solar Eclipse of 8 June 1937

1 OCT 1940 1940 B

Nat. Geog. Soc. Contr. Tech. Pap. Solar Ecl. Ser. #2, p. 78 (1942)
Patos, Brazil
E.O. Hulburt

Mr. Hulburt's participation in the eclipse expedition to Patos, Brazil (7°1'S, 37°17'W) consisted of two experiments "(1) the measurement of the brightness of the zenith sky during morning and evening and twilight and (2) the measurement of the brightness of a selected small area of the sky during the total phase of the eclipse." Although scattered clouds moved in and blocked off the sun (elevation angle approximately 51°47') during midtotality, the horizon sky below 15° was about two-thirds free of clouds.

The brightness measurements of the zenith sky during morning and evening twilight were made with a "calibrated Macbeth illuminometer" whose field of view was "a cone of about 4° angular diameter" and which was fitted with "a blue filter to match the sky color." During the eclipse, the same illuminometer was used but modified slightly "by mounting a lens of focal length 61 mm in front of the sighting tube." The illuminometer was calibrated by means of a standard lamp and was placed in a box which was "mounted in the open on a cement foundation." A 90° rotatable glass prism was mounted on the end of the illuminometer telescope so that "by rotating the box and the prism, the illuminometer could be pointed at any desired region of the sky." During the eclipse the illuminometer "was pointed north-west at an altitude of 45° above the horizon." A horizon photometer

consisting of 6 Photox photoelectric cells, Westinghouse type SW-30, was used to measure i_u, the light flux coming mostly from the illuminated atmosphere around the horizon. The photometer was mounted on top of a pole 11 feet high, and a cover was placed over the photometer for protection from too much direct sunlight. A small blockage of view was provided by some buildings to the south.

Tables 20 and 21 give the brightness data during the first part and the last part of totality respectively with b_s being the sky brightness in erg sec^{-1} steradian^{-1}, α being the microammeter reading from the horizon photometer in microamperes, and i_u being the light flux in erg cm^{-2} sec^{-1} calculated from the microammeter readings. Figure 16 gives a plot of the data.

Table 20. Brightness Data During First Part of Totality

1	2	3	4	5
No.	Time GCT	b_s erg sec^{-1} steradian^{-1} Observed	α micro-amperes	i_u erg cm^{-2} sec^{-1}
1	$11^h43^m34^s$	6.80	10.5	143
2	44	7.02	6.2	84
3	51	7.87	5.5	75
4	44 0	7.22	4.8	66
5	7	7.15	4.3	59
6	49	5.50	3.4	43
7	45 3	4.46	3.4	42
8	19	3.54	2.8	34

Table 21. Brightness Data During Last Part of Totality

No.	Time GCT	microamperes α	i_u erg cm^{-2} sec^{-1}
9	$11^h45^m44^s$	2.9	35
10	46 2	2.8	34
11	9	2.8	34
12	28	2.7	34
13	42	2.7	34
14	57	2.9	37
15	47 14	3.0	39
16	20	3.1	41
17	41	3.6	49
18	48	4.0	55
19	52	4.1	56
20	48 6	5.3	72

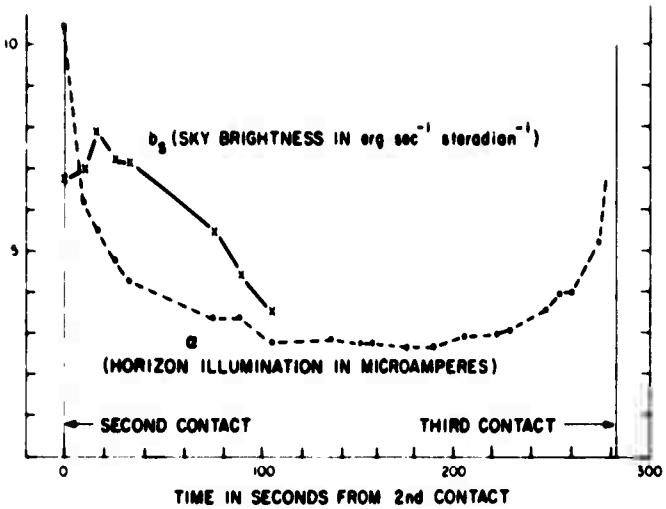


Figure 16. Sky Brightness Data During the Solar Eclipse of 1 October 1940

20 MAY 1947 1947 A

Jour. Roy. Astr. Soc. Canada 43, 229 (1949)
Araxa, Brazil
J. Hargreaves

Although no measurements were taken during the total phase, observations of the light scattered by the sky were taken both before and after totality at Araxa, Brazil ($19^{o}40'.2$ S, $46^{o}56'.5$ W) where the sky was completely overcast during the entire eclipse.

The instrument used was a General Electric Light Meter, Model 8 DW4042, which had been calibrated at Ottawa, Canada with an "artificial sky" of artificial light of colour temperature 6500^{o}K. The meter was "fixed with the sensitive surface horizontal facing the zenith." Two metal screens were used to reduce the total light entering the meter "without making any great change in the opening, which was a hemisphere." Screen "A" had a rectangular hole 1/2 × 3/16 inch, and screen "AA" had a circular hole approximately 1/8 inch in diameter.

Table 22 gives the results of the observations with column 1 giving the time of the reading, column 2 giving the meter reading and the screen used, column 3 giving "the brightness of the sky as deduced from the calibration of the meter" in foot lamberts, and column 4 giving "the cosine of the zenith distance of the axis of the shadow ζ, at observer's time + .456 min."

Table 22. 20 May 1947 Eclipse Results

Time	Meter Reading	Brightness (ft-lamberts)	ζ
11^h00^m	10 AA	1680	0.31701
15	10 AA	1680	0.36672
20	8 AA	1350	0.38285
30	5.5 AA	925	0.41439
40	4.5 AA	755	0.44491
50	5 AA	840	0.47437
12 00	3 AA	505	0.50271
24	70	74.25	0.56585
25	55	58.5	0.56833
26	24	25.5	0.57079
27	11	11.6	0.57324
32	10	10.5	0.58528
33	14	14.8	0.58764
34	30	32	0.59000
35	55	58.5	0.59234
36	70	74.25	0.59467
42	28 A	330	0.60836
45	30 A	355	0.61501
50	53 A	670	0.62583
13 00	11 AA	1845	0.64640
10	16 AA	2660	0.66553
20	16 AA	2660	0.68317
30	19 AA	3155	0.69929

20 MAY 1947 1947 B
Jour. of Geophys. Res. 54, 229 (1949)
Bocaiuva, Brazil
R.A. Richardson & E.O. Hulburt

The eclipse expedition established its camp at Bocaiuva, Brazil ($17^\circ12.'8$ S, $43^\circ41.'3$ W) to make observations of "the brightness of the zenith sky during the penumbra phases of the eclipse, and of the brightness of the zenith sky and the illumination from the sky near the horizon during the umbra phase of the eclipse." During the eclipse, a very thin cirrus more or less veiled the sky.

A calibrated illuminometer with a small opaque screen placed between the sun and the instrument was used to measure the illumination of an area of sky around the sun during the penumbra phases. A photomultiplier photometer described elsewhere by Richardson and Hulburt[23] was used to measure the brightness B of the zenith sky during the penumbra phases and throughout totality. A horizon photometer consisting of 8 Weston photronic cells, each covered with a Viscor filter of greenish glass, was mounted "on a pole about nine feet high in an open

23. Richardson, R.A., and Hulburt, E.O. (1949) J. Geophys. Res. 54:215.

field, with a fair view of the horizon sky in all directions," and was "provided with a cover for protection against direct sunlight" to measure the illumination h from the horizon.

Figure 17 gives a plot of the zenith sky brightness as measured with the illuminometer and Figure 18 shows both the zenith sky brightness B and the horizon illumination h during totality. Table 23 gives the zenith sky and horizon data during totality with column 1 giving GCT, column 2 the zenith sky brightness in candles ft^{-2}, column 3 the reading R of the microammeter of the horizon photometer, and column 4 the horizon illumination h in foot-candles. It was noted that "the brightness of the zenith sky descended to a minimum value of 0.037 ca. ft^{-2} = 12.5 microlamberts" which is "about as bright as the zenith sky when the sun is 7^{o} below the horizon."

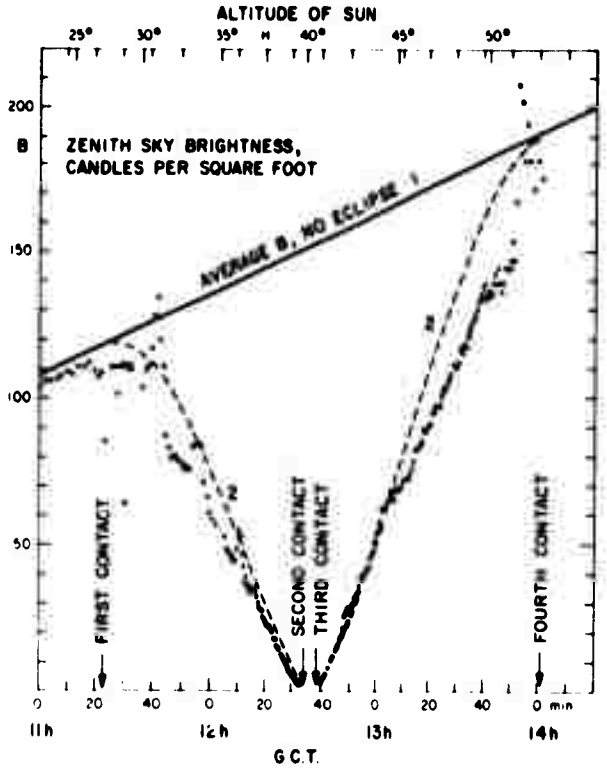


Figure 17. Zenith Sky Brightness and Horizon Illumination During Totality of the Solar Eclipse of 20 May 1947: Dots, observed; curves, theoretical

Table 23. Zen h Sky and Horizon Data During Totality

GCT 12^h+	B	R	h
m s	ca. ft. $^{-2}$	mirco-amp	foot-candle
33 51.0	0.515	....	....
59.4	0.389	....	....
34 06.6	0.306	....	....
13.4	0.223	48.5	....
17.8	0.189	41.3	....
24.8	0.139	29.3	....
30.0	0.111	21.2	....
36.2	.....	14.2	....
46.2	0.053	10.0	....
53.0	0.050	9.1	6.0
57.8	.....	8.8	6.0
35 03.0	0.048	8.3	5.7
16.2	0.044	7.4	4.9
26.4	0.042	7.0	4.4
35.8	0.041	6.8	4.1
46.0	0.039	6.4	3.8
56.2	0.037	6.2	3.6
36 06.0	0.037	6.0	3.4
16.2	0.039	6.0	3.4
26.2	0.037	5.9	3.3
36.4	0.037	6.0	3.3
46.6	0.037	6.0	3.3
56.8	0.038	6.1	3.4
37 07.0	0.037	6.2	3.5
16.4	0.039	6.4	3.6
26.6	0.040	6.8	3.9
36.2	0.043	7.1	4.2
46.4	0.045	7.7	4.6
56.2	0.048	8.3	5.2
38 06.2	0.051	9.0	5.9
16.4	0.060	10.0	6.8
26.4	0.081	11.3	7.7
34.0	0.108	12.8	8.4
44.8	0.217	22.2	....
53.6	0.311	35.0	....
39 01.0	0.412	47.0	....
08.0	0.514	....	....
14.8	0.631	....	....

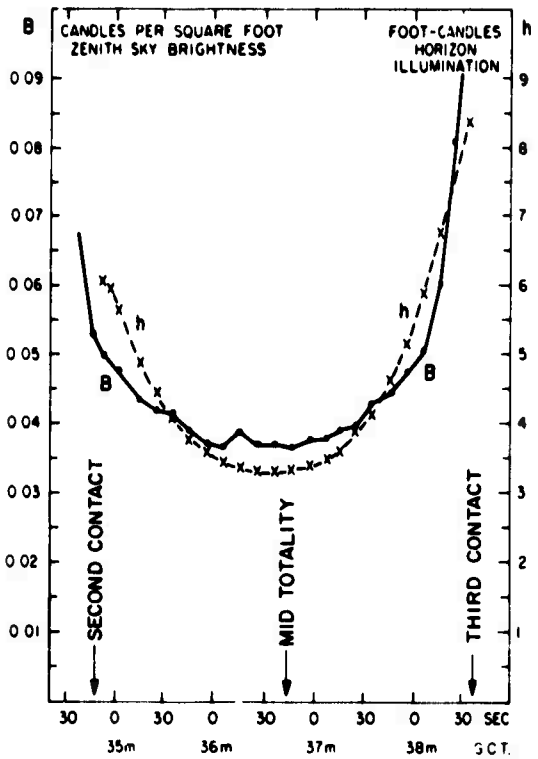


Figure 18. Zenith Sky Brightness and Horizon Illumination During Totality of the Solar Eclipse of 20 May 1947

25 FEB 1952 1952 A
Astrophys. Jour. 123, 9 (1956)
Jebel Dabachi
C.C. Batchelder et al.

During the eclipse, measurements of the "variation of the diffuse light of the sky" were made near Jebel Dabachi (18°32.'5 N, 35°32.'6 W) with "horizontal visibility 7 to the north and 8 to the south." There was no cloud until after mid-eclipse, but then thin and high cirrus were seen.

The electric telephotometer of the Univ. of Ottawa sky photometer "set to receive from an unobstructed field of 1°3 radius" was used to make the measurements. Three neutral density filters were employed, and "during totality, observations were made in 26 positions surrounding the sun."

The results are presented in Table 24 with the radiant intensity being in an arbitrary scale derived by "adjusting the galvanometer deflections for dark current and multiplying by a factor for each neutral density filter used." It was

found that the "zenithal intensities were equal at mideclipse and when the sun was at $95^{o}28'$ zenith distance, during evening twilight of the same day."

Table 24. Photographically Recorded Observations of the Zenith Sky

Universal Time	Neutral Density Filter No.	Galvanometer Deflection	Radiant Intensity
$9^{h}18^{m}27$	3	0.90	188.5
55 1/2	3	0.56	139
19 31	2	7.10	81.8
56 1/2	2	3.70	45
20 30		0.50	9.8
Second contact			
39.7			
44 1/2	1	3.50	3.90
20 1	1	2.96	3.36
12	1	2.70	3.20
not recorded	1	2.70	3.1
Greatest phase			
22 12.5			
59 1/2	1	4.00	4.4
23 29 1/2	1	6.4/5	6.9
35 1/2	1	7.00	7.4
Third contact			
36.7			
24 5 1/2	2	1.80	24
18 1/2	2	3.10	38
43 1/2	2	6.00	70
25 6	2	8.55	97.6
13 1/2	2	9.72	110.3
30	3	0.56	139
46	3	0.73	164
48 1/2	3	0.80	174
53 1/2	3	0.82	177
59	3	0.91	190
26 3	3	0.98	200
9	3	1.05	210
17	3	1.17	228
25	3	1.29	245
39	3	1.49	274
58 1/2	3	1.77	315

25 FEB 1952 1952 B

D. D. Polozhentsev, translated from Russian by the American Meteorological Society. AFCRL Translation T-R-653 (1967)

$41^{o}15'$ N $4^{h}4^{m}58^{s}$ E

Variations of the luminance of the sky in the zone of the bright ring over a period of 120 seconds of the total phase of the eclipse were measured at a location $41^{o}15'$N and $4^{h}4^{m}58^{s}$E. During the measurements there was local light cloudiness, and light cirrus was observed to the south.

Two short-focused photographic cameras of the "Kiev" type, namely camera No. 493333 and camera No. 481443, placed so their "optic axes of the objectives were set horizontally in opposite directions" "with an azimuth equal to the azimuth of the lunar umbra" were used to make the observations. The instruments were calibrated with "a portable tubular photometer," and "a visual photometer of the Rosenberg system," was used for standardization purposes." Ilford-Selo, HP-3 isopan film with a sensitivity of 800 H & D was used. The measurement of the photographs was performed by means of a Hartman microphotometer, and standardized exposures were made to provide a means of determining absolute intensities.

Only one point at $z = 64^{o}$ was successfully measured, and the results are presented in Figure 19 and in Table 25 with the intensities being in stilbs. In Figure 19, Curve I is the luminance of the sky at $z = 64^{o}$, $A = 23^{o}$ taken with Camera No. 481433, and Curve II is the luminance of the sky at $z = 64^{o}$, $A = 50^{o}$ taken with Camera No. 493333.

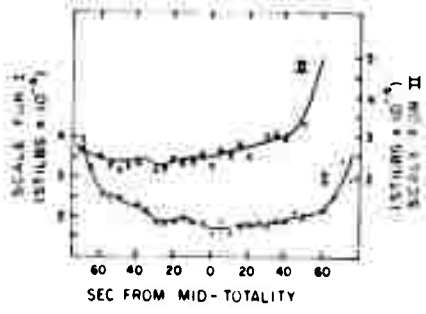


Figure 19. Curves of the Variance of the Luminance of the Sky During the Solar Eclipse of 25 February 1952. I-sky, $z = 64^{o}$, $A = 230^{o}$, camera no. 481443; II-sky, $z = 64^{o}$, $A = 50^{o}$, camera no. 493333

Table 25. Absolute Values of Luminance of the Terrain and the Sky (in stilbs)

No. of exposure	Luminance of sky for z=64°		Luminance of landscape		No. of exposure	Luminance of sky for z=64°		Luminance of landscape	
	Camera No.481443, A = 230°	Camera No.493333, A = 50°	Camera No.481443, A = 230°	Camera No.493333, A = 50°		Camera No.481443, A = 230°	Camera No.493333, A = 50°	Camera No.481443, A = 230°	Camera No.493333, A = 50°
	$\times 10^{-4}$	$\times 10^{-4}$	$\times 10^{-4}$	$\times 10^{-4}$		$\times 10^{-4}$	$\times 10^{-4}$	$\times 10^{-4}$	$\times 10^{-4}$
1	4,0	2,7	15,5	14,8	17	1,6	2,6	9,5	10,7
2	3,3	2,5	15,1	15,8	18	1,8	2,8	11,0	10,5
3	2,6	2,5	13,8	12,9	19	1,8	2,5	11,5	10,0
4	2,5	2,3	11,5	12,3	20	1,8	2,9	11,2	12,0
5	2,5	2,2	11,2	12,0	21	1,8	3,0	10,0	10,7
6	2,3	2,3	10,2	10,7	22	1,9	3,0	10,5	11,7
7	2,3	2,4	10,2	11,5	23	1,9	3,0	13,2	14,1
8	2,2	2,5	9,8	10,7	24	2,1	3,3	15,5	13,5
9	1,9	2,2	9,3	10,0	25	2,0	3,3	15,1	17,0
10	1,9	2,3	8,9	10,7	26	2,1	6,2	17,8	19,5
11	1,9	2,4	9,3	10,2	27	2,1	7,6	26,9	29,5
12	2,0	2,4	9,8	10,0	28	2,5	-	33,8	45,7
13	1,9	2,5	9,8	9,6	29	3,4	-	45,7	89,0
14	1,9	2,6	9,3	8,9	30	2,9	-	-	-
15	1,6	2,3	9,1	10,7	31	-	-	-	-
16	1,9	2,6	9,3	10,5	32	-	-	-	-

25 FEB 1952 1952 C
Jour. of Geophys. Res. 58, 369 (1953)
Aircraft near Red Sea
Wm. A. Rense et al.

Photographs of the skylight in the vicinity of the eclipsed sun were taken "near the time of central eclipse", with the sun at an altitude of about 56°, through a plastic dome of a B-29 flying 32,000 feet above "a point in the shadow path near the Red Sea in Saudi Arabia", and in a "perfectly clear" sky.

The camera used was "a Schmidt camera of aperture F/0.9, covering a field of radius 20°." A Polaroid filter consisting of sixteen 22°5 wedges with points joining at the center was placed immediately in front of the film. Two of the 4 photographs taken on Kodak Super Orthopress film with exposures of around 0.2 second, were photometrically analyzed, and the resulting intensities were corrected for intrinsic instrumental variations and scattering. The photographs were taken with the camera centered on the sun, and good readings were obtained only in the area 5° to 13° from the sun owing to the polarized wedge junctions and wedge effects.

Table 26 summarizes the results from film No. 1 and Table 27 summarizes the results from film No. 2 with the intensities for column 2 being "obtained from a graph of the photometric data in polar coordinates."

Table 26. Sky Brightness From Film No. 1

Angular Distance From Sun (1)	Sky Brightness in Arbitrary Units (2)		Total Sky Brightness (3)	Total Brightness Zodiacal Light (4)	Ratio, p, Polarized Components of Zodiacal Light (5)
	∥	⊥			
o			ergs/cm^2/sec/ steradian	ergs/cm^2/sec/ steradian	
5.5	297	353	0.342	0.144	0.80
7.0	285	337	0.328	0.116	0.79
8.5	271	317	0.309	0.086	0.79
10.0	271	315	0.308	0.071	0.78
11.5	270	311	0.305	0.055	0.77
13.0	271	312	0.305	0.040	0.74

Table 27. Sky Brightness From Film No. 2

Angular Distance From Sun (1)	Sky Brightness in Arbitrary Units (2)		Total Sky Brightness (3)	Total Brightness Zodiacal Light (4)	Ratio, p, Polarized Components of Zodiacal Light (5)
	∥	⊥			
o			ergs/cm^2/sec/ steradian	ergs/cm^2/sec/ steradian	
5.5	341	391	0.343	0.147	0.82
7.0	328	380	0.333	0.123	0.78
8.5	312	358	0.314	0.090	0.77
10.0	312	345	0.308	0.071	0.77
11.5	312	346	0.306	0.057	0.78
13.0	297	330	0.295	0.033	0.74

30 JUN 1954 1954 A
Mon. Not. Roy. Astr. Soc. 115, 629 (1955)
Aircraft - 61°24'N 1°35'W
D. E. Blackwell

During the eclipse, measurements of sky brightness were made from "an open aircraft at an altitude of 30,000 ft. in excellent sky conditions" over a position approximately 61°23.9N and 1°34.6W with the sun at an altitude of about 52°.

A multi-lens camera which gave eight separate images on one photographic plate, an Ilford HP_3 plate with an exposure time of 1 min., was used. Special precautions were taken to minimize scattering in the camera, and a second plate was exposed at the same altitude for the same length of time after the eclipse to provide for calibration against a standard. The sky brightness was determined by "making microphotometer scans of the photographs perpendicular to the ecliptic" and drawing straight lines "touching the curves at the upper and lower ends." It was supposed that these lines gave the intensity of the sky and its variation with altitude.

Table 28 gives the results of the measurements. It was also noted that "Michard et alia" found a sky brightness of 7.90×10^{-10} $\bar{B}_o$ at Khartoum during the 1952 eclipse.

Table 28. Sky Brightness

Altitude	Sky Brightness
58^o	2.48×10^{-10} $\bar{B}_o$
52^o	2.64
46^o	2.80

30 JUN 1954 1954 B
Mon. Not. Roy. Astr. Soc. 116, 69 (1956)
Syd Koster, Sweden
C.W. Allen

During the eclipse, photographic observations were made through thin clouds at Syd Koster, Sweden.

Two cameras, one with a Wratten 47 filter for blue and one with a Wratten 27 filter for red, were used to make the observations. Six blue-sensitive Kodak II-0 plates were exposed through the blue Wratten 47 filter giving an effective wavelength of 4500 Å observed, and six Kodak P_{300} plates were exposed through the red Wratten 27 filter giving an effective wavelength of about 6200 Å observed. Table 29 gives the optical dimensions of the 2 cameras. "Absolute intensity standardization was provided by exposing the eclipse camera A to sunlit white blotting paper." The plates were all measured with a Hilger microphotometer.

"The sky brightness determined by comparison of plate density of the coronal sky with the exposures made with sunlit paper are:

Sky (in blue) = 1.9×10^{-9} mean solar intensity

Sky (in red) = 0.9×10^{-9} mean solar intensity

It was noted that corresponding measurements made at the 1940 eclipse in a clear sky were 1.9×10^{-9} and 1.1×10^{-9}.

Table 29. Optical Dimensions

	Camera A	Camera B
Focal length of camera lens	67.4 cm	75.5 cm
Diameter of stop	8.54 cm	6.54 cm
Aperture (seen from outside)	9.71 cm	6.80 cm
Disk diameter	14.50 cm	10.70 cm
Distance, disk to aperture	447 cm	433 cm
Plate size (square)	15.9 cm	15.9 cm
Field diameter (to 15.0 cm)	$12^{o}.7$	$11^{o}.4$
Radius of Sun (on plate)	3.08 mm	3.45 mm
Radius of umbra (on plate)	3.62 mm	3.40 mm
Radius of penumbra (on plate)	18.25 mm	15.2 mm
Distance, disk to dec. axis	455 cm	

30 JUN 1954 1954 C

"The Airglow and The Aurorae" Permagon Press p. 135 (1955)
Fairplay, Colorado
M.J. Koomen et al.

During the eclipse, observations of the 5577 Å oxygen airglow emission line were made through heavy clouds at Fairplay, Colorado ($39^{o}12'$ N, $106^{o}00'$ W).

A birefringent photometer described elsewhere[24] was directed at a 45^{o} zenith angle "at right angles to the sun's rays where the sky was the darkest" during the measurements.

Figure 20 shows the data obtained for "the 5577 Å line and the sky continuum during the eclipse, corrected for attenuation by clouds using the transmittance curve shown", and Figure 21 shows "the intensity of the sky as measured with an "ordinary" photometer, in the wavelength band 5500-5650 Å."

24. The Airglow and the Aurorae (1955) Permagon Press, p. 355.

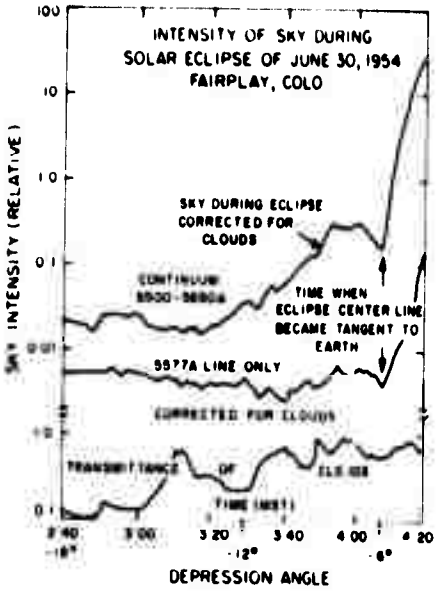


Figure 20. The Intensity of the 5577 Å Line and the Sky Continuum During the Eclipse of 30 June 1954, Corrected for Attenuation by Clouds Using the Transmittance Curve Shown

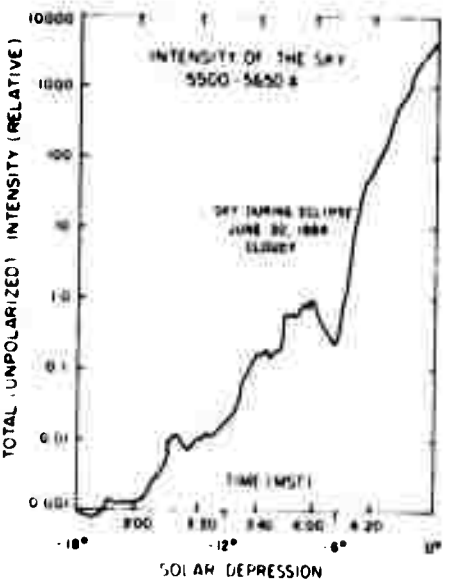


Figure 21. The Intensity of the Sky in the Wavelength Band 5500-5650 Å During the Eclipse of 30 June 1954

30 JUN 1954 1954 D

"The Measurement of Colour" D. Van Nostrand Co. Princeton, N.J. p. 256 (1964)

Grebbestad, Sweden

W. D. Wright

Measurements of the colour of the sky were made at Grebbestad, Sweden "in an azimuth plane 90° round from the sun and at a height of 40° above the horizon," by means of a colorimeter.

Although the sky was cloudy, the variation in sky luminance during the eclipse was recorded and is shown in Figures 22 and 23.

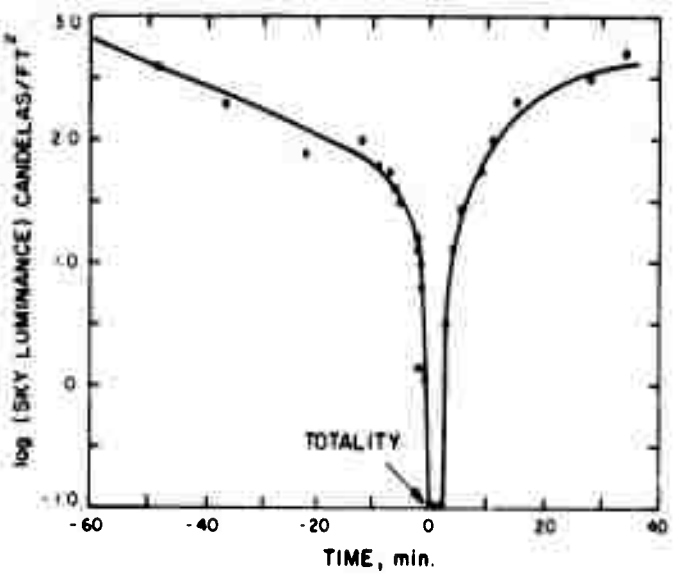


Figure 22. Variation in Sky Luminance During the Total Solar Eclipse of 30 June 1954

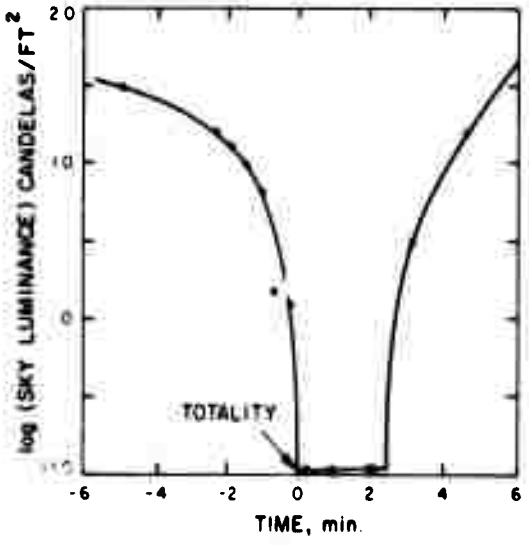


Figure 23. Variation in Sky Luminance Shortly Before, During, and Immediately After the Total Solar Eclipse of 30 June 1954

2 OCT 1959 1959 A
Astrophys. Jour. 133, 616 (1961)
Kidal & Tanout, French West Africa
E. P. Ney at al.

Background skylight intensity was measured in each of two wavelength regions, 4750 Å and 8300 Å, at Kidal (18°50' N, 1°12' E) and Tanout (14°55' N, 8°51' E) both in French West Africa. The sky was clear at both stations with the solar zenith angle being 26°.0 at Kidal and 31°.5 at Tanout during totality.

The equipment used at each site was identical and is described elsewhere by Ney et al.[25] The telescopes were calibrated relative to the average solar surface brightness, to provide for the absolute determination of the sky brightness. The average surface brightness of the sky between 5 and 13.5 solar radii at both the effective wavelengths was measured.

It was found that "average value of the visible intensity was 9×10^{-10} and that of the infrared was 2.7×10^{-10} with the units being average surface brightness of the sun.

15 FEB 1961 1961 A
NASA TT F-204 p. 75, Aurora and Airglow, Edited by V. I. Krasovskiy
Aircraft near Rostov
F. K. Shuyskaya

Spectrographic observations "to study the radiation of the Earth's upper atmosphere" were made from an aircraft at an altitude of 10 km in the region of Rostov (47° N, 39° E) "at an azimuth opposite to the solar azimuth, at the angle of 23° to the horizon." During the eclipse, the sun was at an elevation angle of 27°36', and a dense cloud bank lay below the aircraft at an altitude of about 7,000 m.

The properties of the films used can be found elsewhere[26] as can a description of the spectrographs.[27] Table 30 gives the data on the apparatus used.

The results are listed in Table 31 with column 2 giving "directly measured intensities (at the zenith) of emissions of the natural radiation of the earth's atmosphere during the total phase of the solar eclipse." The error in absolute calibration could have "reached a factor of 2."

25. Ney et al (1960) Astrophys. J. 132:812.
26. Yesipov, V. F. (1960) Astronom. J. 37:1102.
27. Galperin, G. I., et al (1957) Mem. Soc. Roy. Sci. Liege 18:68.

Table 30. Data on Apparatus

Δ λ in Å	Type of Film	Duration of Exposure	Instrument	Dispersion A/mm	Relative Aperture of Camera	Width of Instrument Slit, mm
3850-4600	A-650	3 min*; 30 sec*	SP-48	~ 90	1:0.8	0.2; 0.1
3900-5000	A-650	3 min*; 30 sec*; 10 sec*	SP-47	~200	1:1	0.3; 0.2; 0.1
5800-7000	A-700	3 min; 30 sec	SP-48	~ 30	1.0.8	0.2; 0.1
10000-11000	A-650	6 min	SP-50 with FKT-1	~ 90	1:1.5**	0.1

*Overexposed.
**Relative aperture without electron-optical converter.

Table 31. Intensities of Emissions (in kilorayleighs)

λ in Å	Eclipse of 15 Feb 1961	Intensity Outside Eclipse According to Data for 15 Feb 1961
10,830	1	4
6,300	5	30
5,893	6	100
4,368	1.6	11
3,914	12	28

15 FEB 1961 1961 B

Translated from Academia Republicii Populare Romine. Studii si Cercetari de Astronomie se Seismologie. Bucharest. 7, 141-144 (1961)
Bucharest, Rumania
C Predescu

Measurements to study "the variation in lighting intensity, on a horizontal surface, by the diffuse solar radiation", and "the behavior of radiation in various ranges of the spectrum" were made at Bucharest during the eclipse. Cloudiness varied between 8/10 and 10/10 stratocumulus clouds.

Five selenium photocells, 4 of which were fitted with interferential filters, were mounted on a wooden frame and placed on a horizontal carrier in a field of thin grass. The filters used had maximum sensitivities for the 427 mμ, 476 mμ, 527 mμ, and 1001 mμ wavelengths. The photocells were connected to an electronic recording device which plotted "5 curves representing the variation of light

intensity on a horizontal surface, produced by diffuse solar radiation" during the eclipse. A lux-meter was connected to the photocells after the eclipse to provide a method for transforming the eclipse measurements into photometric units.

Table 32 gives the recordings made during the eclipse and their equivalence in lux, and Figure 24 gives the plot of light intensity in lux versus time for the 5 photo cells.

Table 32. Recordings Made During Eclipse and Equivalent in Lux

	Photocell No 1 Filter 427 mμ		Photocell No 2 Filter 476 mμ		Photocell No 3 Filter 527 mμ		Photocell No 4 Filter 1001 mμ	
9^h23^m	701 div	50 lux	645 div	58,5 lux	1000 div	43,9 lux	880 div	41,8 lux
9 24	692	49,6	630	57,2	965	42,7	890	41,0
9 25	683	49,2	625	56,7	992	43,6	852	40,7
9 26	650	47,8	593	53,8	930	41,6	823	39,4
9 27	600	45,9	550	50,0	833	38,6	770	37,2
9 28	587	45,0	540	49,1	842	38,9	747	36,3
9 29	552	43,5	510	46,4	792	37,2	696	34,1
9 30	519	42,1	470	42,9	683	33,6	640	31,7
9 31	450	39,3	412	37,8	575	30,2	590	29,6
9 32	430	38,4	400	36,7	560	29,8	567	28,7
9 33	440	38,8	410	37,6	585	30,5	576	29,0
9 34	459	39,6	440	40,3	635	33,0	600	30,0
9 35	507	41,6	475	43,3	766	36,4	620	30,8
9 36	453	39,4	415	38,0	600	31,0	590	29,6
9 37	375	36,1	350	32,3	486	27,3	482	25,2
9 38	355	35,3	320	30,0	490	27,5	465	24,4
9 39	307	32,7	285	28,4	420	25,1	400	21,8
9 40	284	30,5	270	27,7	375	23,2	378	20,9
9 41	272	29,3	260	27,3	382	23,5	372	20,7
9 42	250	27,2	245	26,5	360	22,3	340	19,3
9 43	230	25,3	220	24,3	290	18,7	295	17,5
9 44	213	23,7	205	23,0	277	17,9	280	16,9
9 45	200	22,5	180	19,3	245	16,0	245	15,5
9 46	170	20,0	160	16,2	203	12,6	206	14,4
9 47	148	18,0	143	13,6	182	10,9	187	13,1
9 48	123	16,1	120	10,3	150	8,3	154	10,4
9 49	106	14,9	102	7,8	163	9,4	177	8,3
9 50	100	14,4	90	6,1	103	4,6	110	6,2
9 51	78	12,9	77	3,7	80	2,4	85	3,1
9 52	70	12,3	67	1,3	68	1,3	77	1,8
9 53	62	11,7	57	0	58	0,3	66	0
9 54	62	11,7	57	0	58	0,3	61	0
9 55	62	11,7	57	0	62	0,7	66	0
9 56	71	12,4	64	0,2	67	1,1	72	0,5
9 57	76	12,7	74	2,7	74	1,8	80	2,5
9 58	90	13,7	87	5,7	87	3,0	95	4,3
9 59	102	14,6	100	7,5	110	5,2	124	7,9
10 00	128	16,4	123	10,8	150	8,3	153	10,3
10 01	145	17,7	142	13,5	190	11,5	192	13,6
10 02	166	19,5	160	16,2	210	13,2	212	14,6
10 03	168	19,7	164	16,8	210	13,2	214	14,7

Table 32 (Contd.). Recordings Made During Eclipse and Equivalent in Lux

	Photocell No 1 Filter 427 mμ		Photocell No 2 Filger 476 mμ		Photocell No 3 Filter 527 mμ		Photocell No 4 Filter 1001 mμ	
10^h04^m	190 div	21,6 lux	188 div	20,6 lux	240 div	15,6 lux	250 div	15,7 lux
10 05	230	25,3	220	24,3	305	19,4	303	17,9
10 06	243	26,6	232	25,5	325	20,5	316	18,4
10 07	250	27,2	236	25,8	325	20,5	325	18,8
10 08	270	29,1	260	27,2	365	22,6	360	20,2
10 09	300	32,0	300	29,2	420	25,1	410	22,2
10 10	370	35,9	350	32,3	526	28,6	485	25,3
10 11	385	36,1	362	33,4	543	29,2	510	26,3
10 12	392	36,8	375	34,5	560	29,7	520	26,7
10 13	500	41,3	470	42,9	665	33,0	600	30,0
10 14	560	43,9	530	48,2	825	38,3	672	33,1
10 15	560	43,9	520	47,3	750	35,8	690	33,8
10 16	565	44,1	530	48,2	770	36,5	720	35,1
10 17	610	46,0	560	51,8	840	38,8	768	37,2
10 18	677	49,0	623	56,5	945	42,1	805	38,7
10 19	667	48,6	630	57.2	975	43,1	850	40,6
10 20	750	52,1	700	63,4	1000	43,9	940	44,3

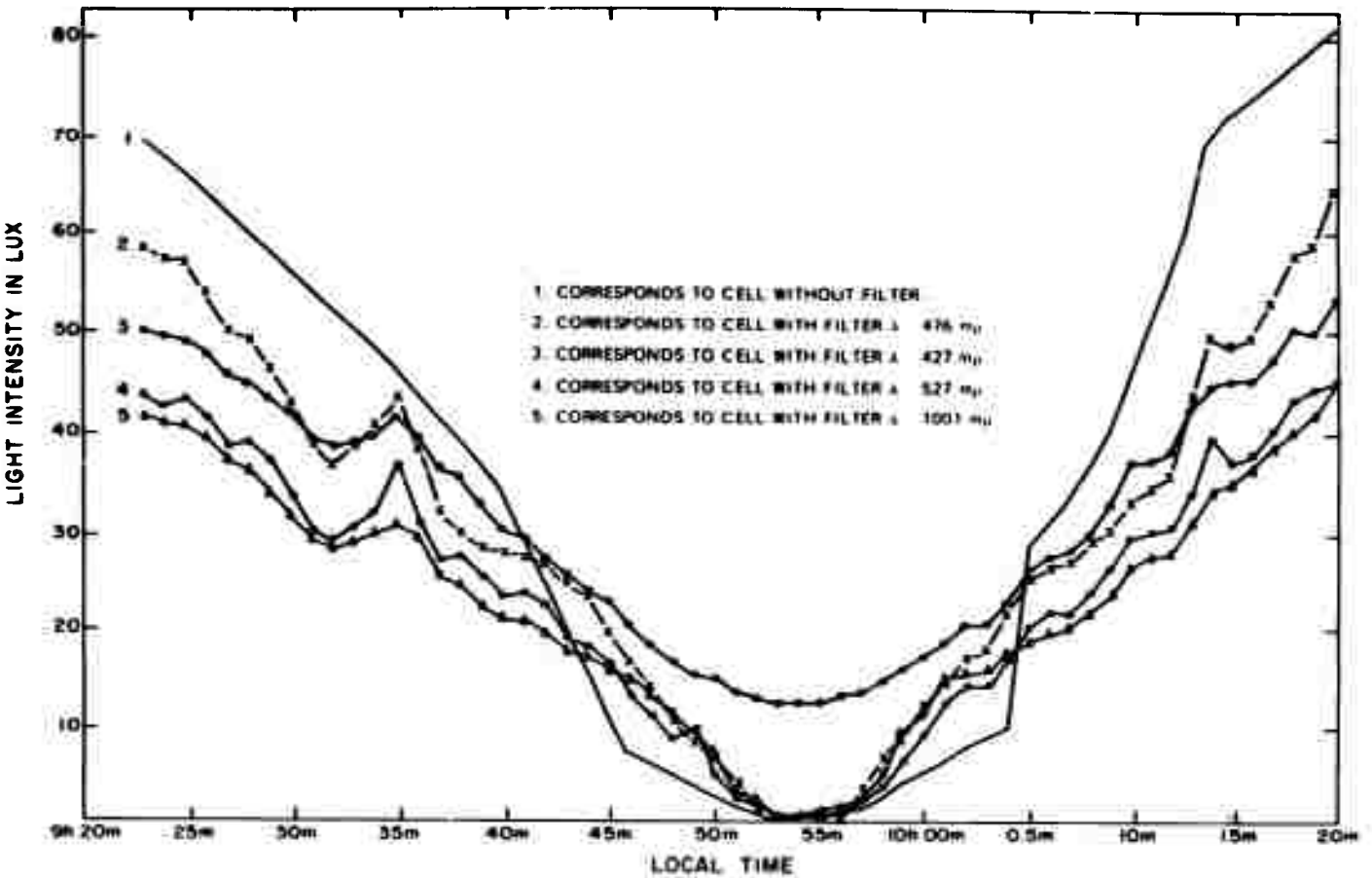


Figure 24. Variation of Illumination on a Horizontal Surface During the Total Solar Eclipse of 15 February 1961 Measured at Bucharest

15 FEB 1961 1961 C

Translated from Geofisica Pura E Applicata 48, 193-198 (1961)
Viareggio, Italy
E. de Bary, K. Bullrich & D. Lorenz

Photometric measurements of sky radiation were taken at Viareggio, Italy ($43^{o}44'$ N, $10^{o}15'$ E) during the eclipse.

A photometer with an objective opening angle of 14^{o} was directed "to a point lying at 90^{o} vertical distance from the sun. "The measuring element utilized was a multiplier," and the "amplified intensities were read from a multiflex galvanometer into a tape recorder."

Results are given in Figures 25 and 26 with Figure 25 showing "the relative intensity of the sky radiation for the three wavelengths chosen, during the partial and total solar eclipses, graphed versus time respectively versus the height of the sun [relative to the horizon]. A logarithmic scale is used, with all measurements given relative to the radiation intensity during the total eclipse; all three intensities during the total eclipse have the unit value. For comparison purposes the values measured on the following day, during the same time interval, are also given."

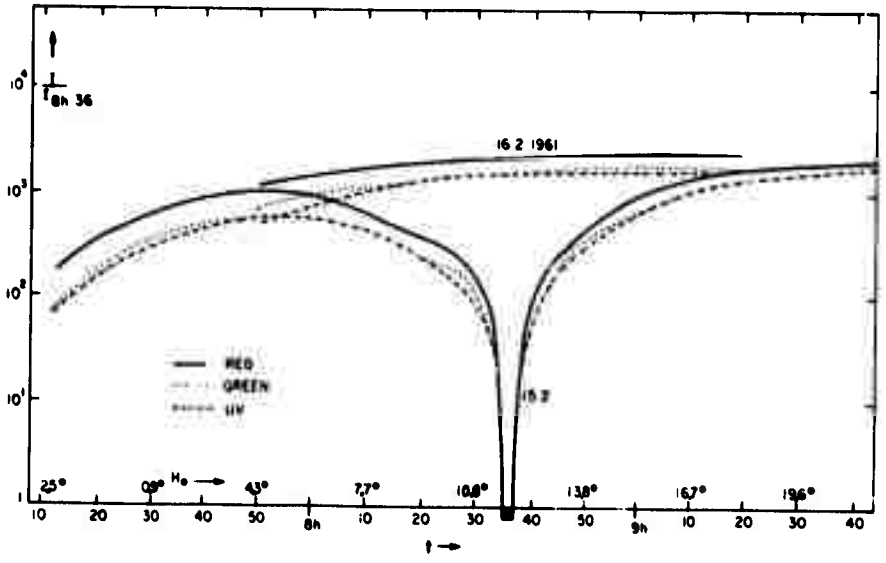


Figure 25. Sky Radiation at 90^{o} Vertical Distance From the Sun During the Total Eclipse of 15 February 1961 and 16 February 1961 at the Same Time at Viareggio, Italy

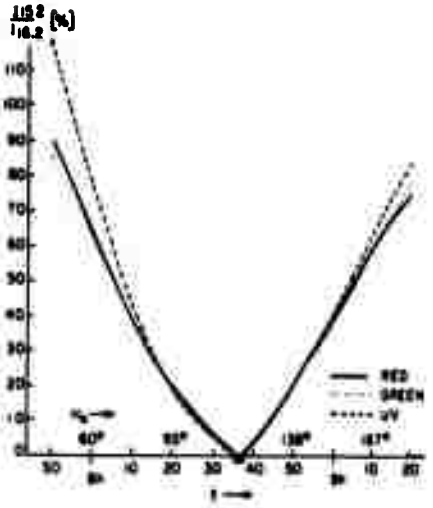


Figure 26. Sky Radiation at 90° Vertical Distance From the Sun, on 15 February 1961, Given in Percent, Relative to the Sky Radiation on 16 February for the Same Time Interval

Figure 26 shows the "sky radiation at 90° vertical distance from the sun, on 15 Feb 1961, given in percent, relative to the sky radiation on 16 Feb for the same time interval. The eclipse measurements of sky radiation were compared with those occurring at dusk on the evening of 14 Feb, and it was noted that the intensities were the same when the sun was "between -6° and -7° from the horizon."

20 JULY 1963 1963 A

Planet Space Sci. 12, 875 (1964)
Aircraft near Great Slave Lake, Canada
C.S. Deehr & M.H. Rees

Observations of atmospheric emissions of 5577 Å, 6300 Å and 5890-5896 Å were made from an unpressurized aircraft at 31,500 ft. in the region of Great Slave Lake, Canada (61°25' N, 117°30' W). During the eclipse the sky was partly overcast, but it was "fairly clear above and below the aircraft."

Four photometers "of the type originally used by Roach and Pettit[28]" whose telescopes "were fitted with narrow band interference filters (10 Å half-transmission width) with peak transmission at the following wavelengths: 4278 Å,

28. Roach, F.E., and Pettit, H. (1960) J. Geophys. Res. 56:325

4861 Å, 5577 Å, and 6300 Å", were used to make the observations. Each telescope had a field of view of "1° in the Sun's meridian and 4° in the direction of travel" (east) and had a circular sheet of HN-38 polaroid, rotated at 4 rev/min., placed in front of it. The photometers "scanned the sky from 45° S to 45° N in the sun's meridian through a window in the top of the fuselage." Table 33 gives the interference filter photometer data.

The results are presented in Figures 27 and 28 with Figure 27 giving the variation of the solar flux "with time from three minutes before and throughout totality", and Figure 28 giving the zenith radiant flux as a function of wavelength at midtotality and at El Paso, Texas in the morning twilight at a solar depression angle of 7°48'.

Table 33. Interference Filter Photometer Data

Wavelength (Å)	Effective Pass Band (Å)	Spectral Radiance of Continuum at Midtotality (kR/Å)	Solar Flux Outside Atmosphere (kR/Å)	Polarization at Midtotality
4278	11.5	0.98	4.15×10^4	0.04
4860	5.72	0.76	5.28×10^4	0.07
5577	14.4	0.41	5.46×10^4	0.05
6300	24.6	0.12	5.49×10^4	0.12

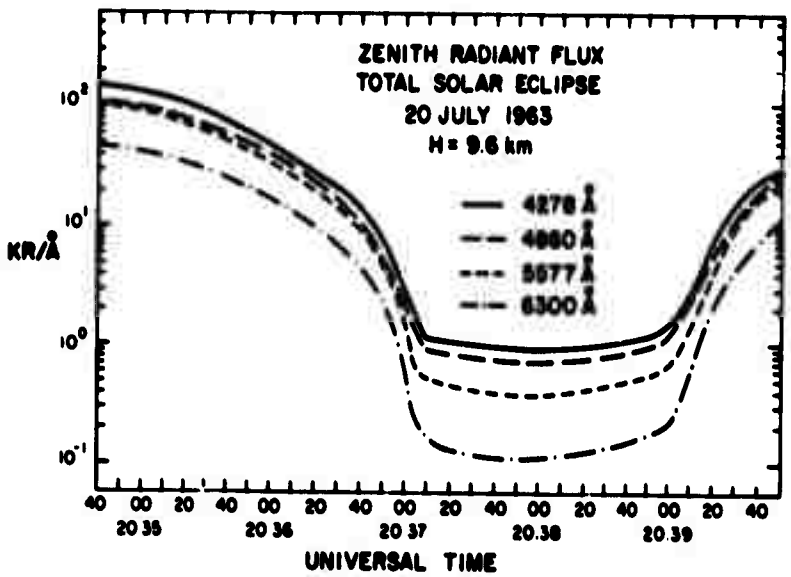


Figure 27. The Zenith Radiant Flux Measured During the Solar Eclipse of 20 July 1963

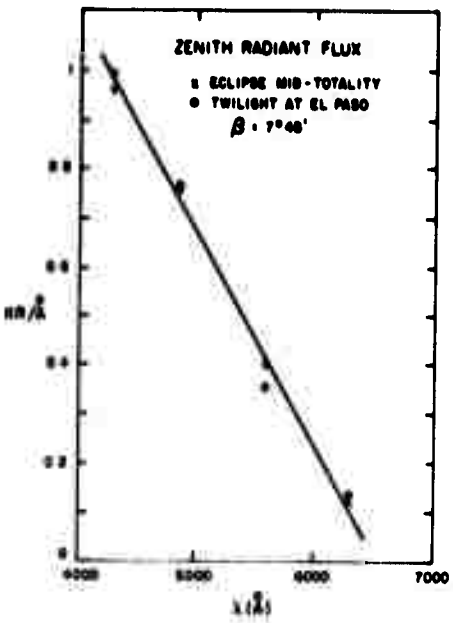


Figure 28. The Zenith Radiant Flux as a Function of Wavelength at Midtotality of the Eclipse of 20 July 1963 and in the Morning Twilight at El Paso, Texas

20 JUL 1963 1963 B - 1963 C - 1963 D
Astrophys. Jour. 140, 292 (1964)
The Forks, Maine; Aircraft over Canada; Balloons over Maine
F.C. Gillett et al.

The brightness of the sky was measured at ground level at The Forks, Maine, at 40,000 ft from photographs taken by Astronaut Scott Carpenter in a jet aircraft over Canada, and at 110,000 feet from photographs taken by cameras flown on Balloons launched from Hogan Airfield near North New Portland, Maine. The cloud cover at The Forks, Maine broke just before totality, and the eclipse was seen.

The instruments used in Maine are described elsewhere by Ney et al.[25] From the balloons, 35 mm cameras with no shutters were used in such a way that continuous 360° panoramic photographs of the sky were obtained. The cameras were of focal length 23 mm at f/0.6 with an angular field of 60°, and calibration was such that there was an "estimated accuracy of absolute intensities of about ± 10 per cent." Kodak Tri X-Pan film and ultra-speed Ansco 529 color film were both used with no filters.

Figure 29 shows the brightness of the sky as a function of atmospheric pressure which was plotted from the measured data. It was noted that "it would be

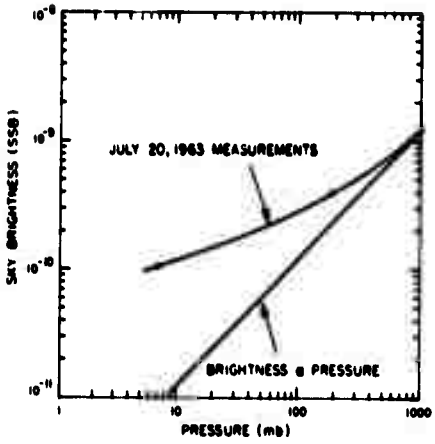


Figure 29. Sky Brightness at the Elevation of the Sun During the Eclipse of 20 July 1963 as a Function of Atmospheric Pressure

possible to reduce sky brightness in the wavelength range between 4000 and 6500 Å to about 5×10^{-11} of the average surface brightness of the sun if the eclipse were to occur at the zenith."

20 JUL 1963 1963 E
Applied Optics 5, 787 (1966)
Hermon, Maine
W. E. Sharp et al.

During the eclipse, "the zenith skylight intensity was measured, with a resolution of 10 Å, over the wavelength range from 5200 Å to 6400 Å" at Hermon, Maine (44°48' N, 88°57' W). During the total phase, the sun's elevation was 25°, and although grey cumulus clouds floated about, "the zenith remained clear throughout the period of the measurements."

The instrument used for the measurements was a "1-m Ebert Fastie spectrometer with fixed slits set for a resolution of 10 Å." The spectrometer had Number 96 Kodak Wratten neutral-density filters placed over the entrance slit, which was "shaded from direct sunlight", was positioned to "accept the light from the zenith sky with a cone of acceptance of 0.01 sr solid angle," and scanned the wavelength from 5200 Å to 6400 Å every 15 sec. Although the absolute intensity calibration of the instrument was not known at the time of the eclipse, methods were used that rendered the error in the absolute calibration to be estimated at "not more than a factor of 2."

The results are plotted in Figures 30 and 31 with Figure 30 being a plot of the absolute zenith intensity at 6000 Å and at 5200 Å, and Figure 31 being a plot of the intensity distribution with wavelength at totality compared with the twilight sky at a solar depression of 5.1°. It was noted that the minimum intensity at 5200 Å was 19.6 kr/Å.

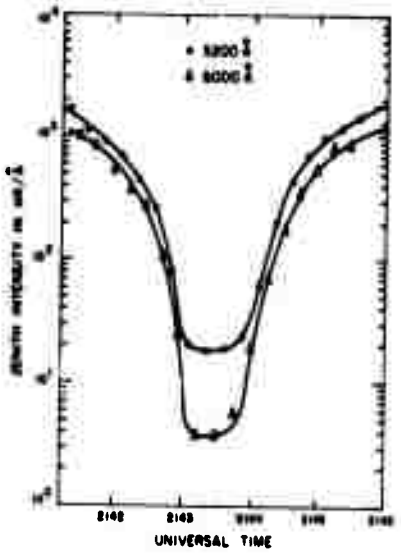


Figure 30. The Absolute Zenith Intensity of 5200 Å and 6000 Å Measured During the Total Solar Eclipse of 20 July 1963

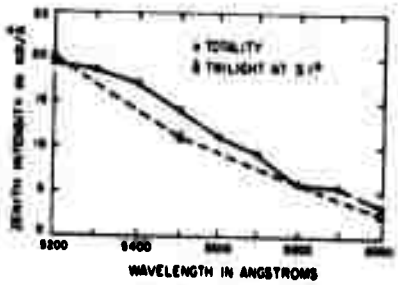


Figure 31. A Comparison of the Intensity Distribution With Wavelength at Totality of the Eclipse of 20 July 1963 and the Twilight Sky at a Solar Depression of 5.1°

20 JUL 1963 1963 F
Annales De Geophysique 23, 339 (1967)
Aircraft near Fort Providence, Canada
J.G. Moore & D. Lamp

The brightness of the sky in seven colors, was measured from a jet aircraft flying at 40,500 feet over the area of Fort Providence, Canada.

The photometer used to make the measurements consisted of four detectors and four telescopes which each had a circular field of view "defined by a cone of apex angle 1°" and three of which contained two interchangable filters. A more detailed description may be found elsewhere.[29] Seven filters were used to isolate narrow spectral bands centered on 3914 Å, 5274 Å, 5577 Å, 5893 Å, 6018 Å, 6300 Å, and 6561 Å. The photometer was installed in a special gimballed window

29. Moore, J.G. (1964) ISA Transactions 3:301.

in the aircraft and "scanned up the sun's vertical between horizon and the sun" which appeared at about 49° elevation angle during the eclipse.

Figures 32 A-G give the results of the "averaged sky brightness variations in each of seven colors as a function of elevation angle and time. The curves labelled 1 in each of the diagrams indicates the sky brightness about 5.5 minutes before totality began, that labelled 2, during totality, and those labelled 3 and 4 about 2.6 and 8.0 minutes after totality ended." The dashed curves on the graphs are presented "so that a familiar comparison of relative brightness measurements during totality can be made" and represent "the zenith sky brightness as a function of solar altitude during twilight on the ground at China Lake, California." It was noted that the point of minimum sky brightness during totality was "equivalent to the zenith twilight sky brightness when the solar depression angle is about 5°2." F.C. Gillett provided J.G. Moore with a brightness curve "obtained by densitrometry of a photograph taken at 110,000 feet from a balloon," and Figure 33 shows the "sky brightness in units of solar surface brightness as a function of angular distance from the sun" for both the balloon data and 5270 Å on the flight data.

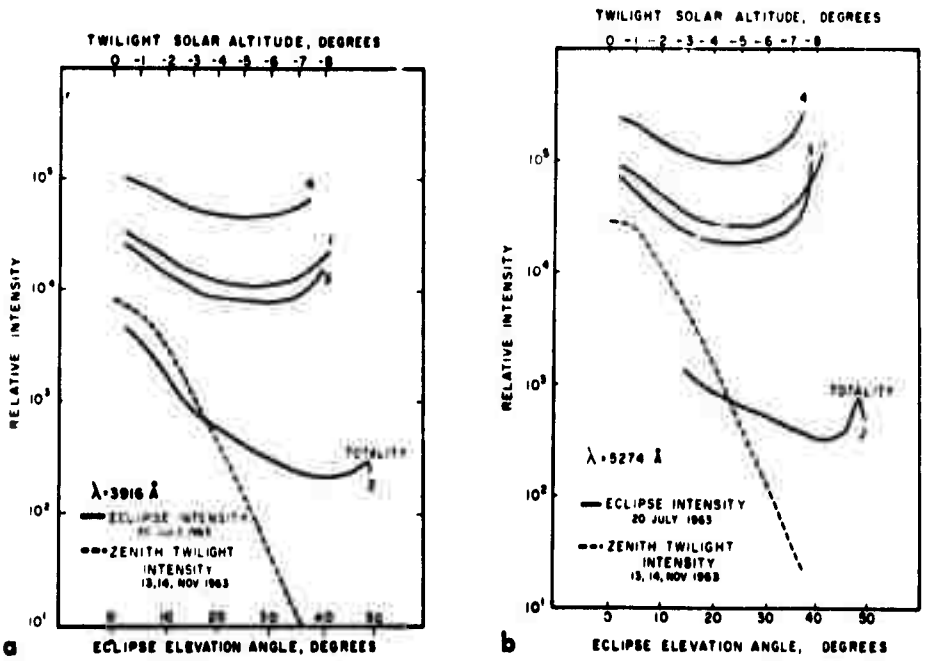


Figure 32. Variation of Sky Brightness in Arbitrary Units as a Function of Elevation Angle During the Total Solar Eclipse of 20 July 1963, and the Zenith Twilight Intensity in the Same Units as a Function of Solar Depression Angle. Curve 1-sky brightness about 5.5 minutes before totality; curve 2-sky brightness during totality; curve 3-sky brightness about 2.6 minutes after totality; curve 4-sky brightness about 8 minutes after totality; and dotted curve-zenith twilight intensity measured at China Lake, California, 13 and 14 November 1963

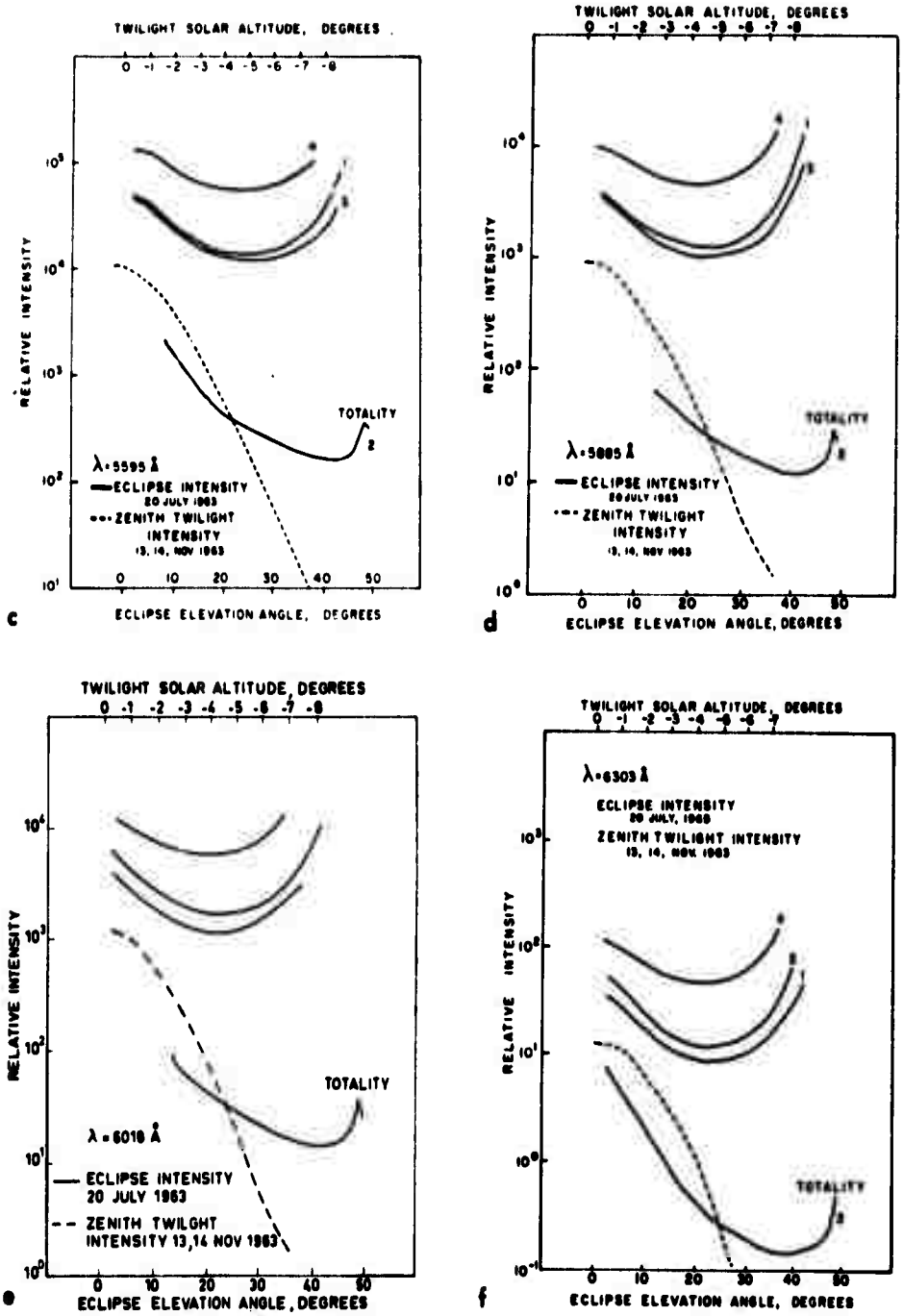
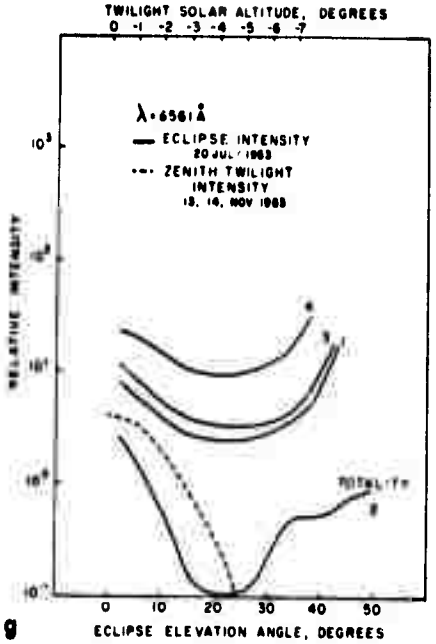


Figure 32. Variation of Sky Brightness in Arbitrary Units as a Function of Elevation Angle During the Total Solar Eclipse of 20 July 1963, and the Zenith Twilight Intensity in the Same Units as a Function of Solar Depression Angle. Curve 1-sky brightness about 5.5 minutes before totality; curve 2-sky brightness during totality; curve 3-sky brightness about 2.6 minutes after totality; curve 4-sky brightness about 8 minutes after totality; and dotted curve-zenith twilight intensity measured at China Lake, California, 13 and 14 November 1963



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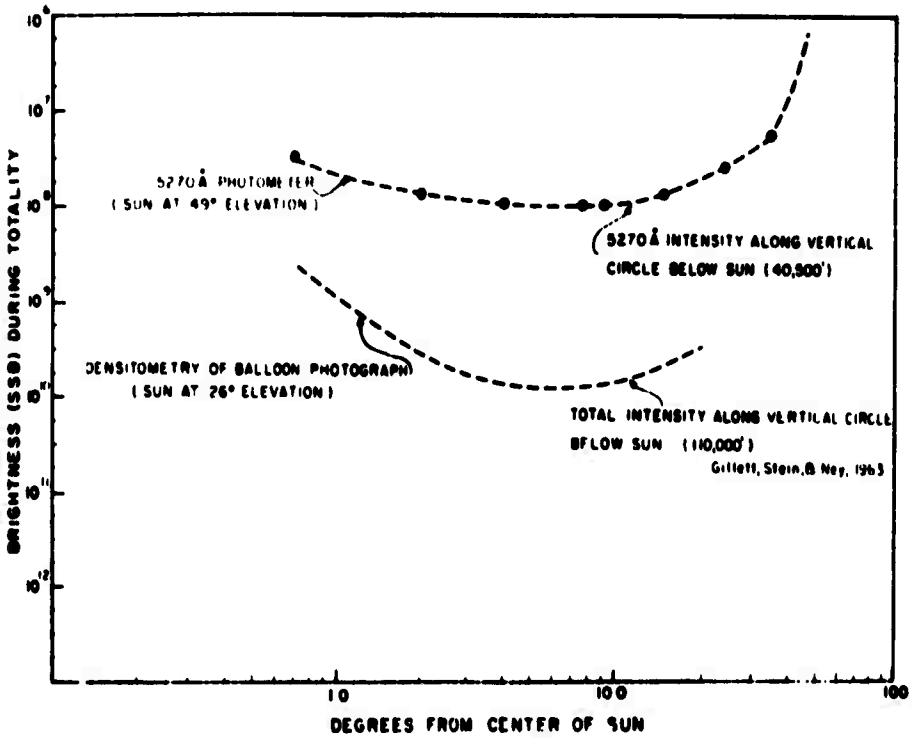

Figure 33. Sky Brightness in Units of Solar Surface Brightness as a Function of Angular Distance From the Sun During the Total Solar Eclipse of 20 July 1963

30 MAY 1965 1965 A

Annales De Geophysique 22, 147 (1966)
Aircraft near Bellingshausen Atoll
J.G. Moore & C. R. Nagaraja Rao

Measurements of two spectral intervals (bandwidth ~50 Å) centered on 4750 Å and 6010 Å were made during the eclipse from an aircraft flying at 40,000 feet over Bellingshausen Atoll (15°05' S, 154°00' W) in the Pacific Ocean. A thin cirrus cloud deck was beneath the plane during the eclipse run, but the sky was clear overhead. The eclipse was observed at an elevation angle of about 43°.

Two telephotopolarimeters with acceptance angles of 4°00' were used to make the measurements. The telephotopolarimeters consisted basically of EMI Type 9502-B photomultiplier tubes, KN-36 polaroids which were rotated at 120 rpm, interference filters with peak transmissions centered on 4750 Å and 6010 Å and widths of about 50 Å, and various field electronics. During the eclipse the instruments were directed at a point in the sky about 90° from the sun.

Figure 34 gives the results of the sky brightness measurements made during the eclipse.

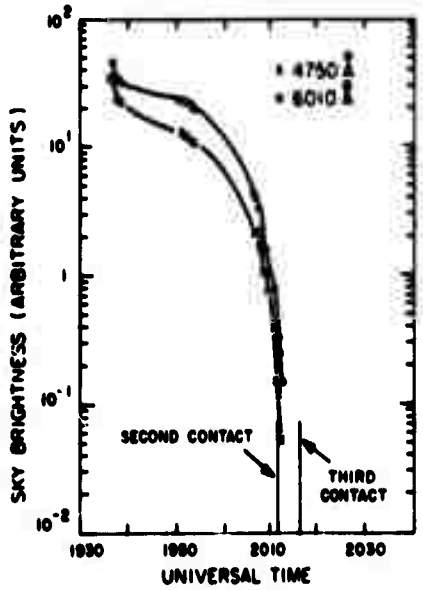

Figure 34. Measured Values of Sky Brightness During the Eclipse of 30 May 1965

12 NOV 1966 1966 A
Applied Optics 7, 705 (1968)
Quehua, Bolivia
B. S. Dandekar

The brightness of the zenith sky in the 5300-6600 Å region was measured at Quehua, Bolivia (20°.12 S, 66°.95 W) with the sun's altitude about 51° during the eclipse. Although there was "a very thin streak of stratus cloud about 30° above the western horizon until around midtotality," the region of the sky "near the sun and at the zenith was clear and cloudless, during the entire period of the eclipse."

The instrument used was "an Ebert-Fastie 1-m scanning spectrometer with adjustable slitwidth using an EMI9558 detector, which has a trialkaline cathode with S20 response." A Kodak Wratten filter ND3.0 was used at the entrance of the slit. The stability and sensitivity of the instrument "was checked against a continuum of known distribution during the entire period of observation." Observations during the eclipse "consisted of 20-sec. scans with a resolution of about 1 Å."

Figure 35 gives "the plot of the continuum of the zenith sky illumination at 5300 Å, 5600 Å, 5900 Å, and 6300 Å around the period of totality" and "the average

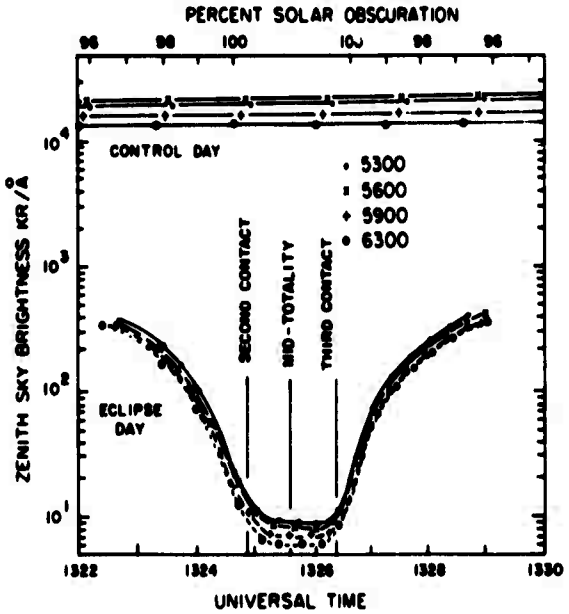

Figure 35. The Zenith Sky Brightness for the Continuum at 5300 Å, 5600 Å, 5900 Å, and 6300 Å for a Normal Day and During Totality of the Solar Eclipse of 12 November 1966

zenith sky illumination for the same wavelength region and over the same time interval for the uneclipsed sun, observed on the three days preceding the eclipse." The "average zenith sky illumination for the uneclipsed sun and minimum observed during totality" are listed in Table 34 with I_n being the average brightness of the zenith sky at a solar elevation of 51°, I_t being the brightness of the zenith sky at totality, and r being I_t/I_n. It was noted that the illumination of the sky at mid-totality was approximately equal to an illumination at twilight with a solar depression angle of 4.1°. Table 35 gives a summary of "results of the zenith sky brightness obtained by other workers for different solar eclipses."

Table 34. Eclipse Data for 12 November 1966 from Quehua, Bolivia

Wavelength in Å	Zenith Sky Illumination kR/Å		Ratio
	I_n	I_t	r
5300	2.089×10^4	9.343	0.447×10^{-4}
5600	2.239×10^4	8.414	0.376×10^{-4}
5900	1.778×10^4	7.499	0.422×10^{-4}
6300	1.496×10^4	6.310	0.422×10^{-4}

Table 35. Observed Sky Brightness During Some Total Solar Eclipses

Date	Site of Observation and Elevation	Sky Brightness as Reported*	Equivalent Brightness at 5600 Å in kR/Å	Blackbody Temperature in °K
8 June 1918	Rock Spring, Wyo.	1/6000 of normal	99.0	-
21 Sept. 1922	Wallal, Australia	Solar depression of 7°	-	-
24 Jan. 1925	American continent	0.24 fc, 5:30 p.m. twilight in New York	13.3	-
14 Jan. 1926	Sumatra	0.138 fc	7.7	-
29 June 1927	Bentham U.K.	0.5 fc	27.8	-
	Southport U.K.	0.1 fc	5.6	-
	Leyburn	0.18 fc	10.0	-
	Criccieth	0.05 fc	2.8	-
9 May 1929	Alor Star, Malaya	0.15 fc	8.3	-
21 Oct. 1930	Niuafou	0.378 fc	21.0	-

Table 35 (Contd.). Observed Sky Brightness During Some Total Solar Eclipses

Date	Site Observation and Elevation	Sky Brightness as Reported*	Equivalent Brightness at 5600 Å in kR/Å	Blackbody Temperature in °K
31 Aug. 1932	Lancaster, N. H.	0.9 mL	14.8	-
19 June 1936	Leningrad University	1.8×10^{-4} of normal	107.0	-
8 June 1937	9°49.5'N 133°38'W	1/5000 of normal	119.0	-
1 Oct. 1940	Patos, Brazil	34 erg $cm^{-2}s^{-1}$	10.6	-
		1.9×10^{-9} BO at 4500 Å and 1.1×10^{-9} BO at 6200 Å	15.2	15,500
21 Sept. 1941	Alma Ata	0.9×10^{-4} lm	4.6	-
9 July 1945	Lakhdenpokhya	1.77×10^{-4} stilb at 4600 Å and 0.71×10^{-4} stilb at 6800 Å	6.7	15,600
20 May 1947	Bocaiuva, Brazil 660 m	0.037 fc	2.1	-
25 Feb. 1952	not mentioned	7.9×10^{-10} BO at 6400 Å	9.8	-
	Jebel Dabachi 650 m above msl	Solar depression of 5°28'	-	-
30 June 1954	Syd Koster, Sweden	1.9×10^{-9} BO at 4500 Å and 0.9×10^{-9} BO at 6300 Å	13.6	16,400
	61°23.9'N & 1°34.6'W 9.2 km	2.64×10^{-10} BO at 6300 Å	3.3	-
2 Oct. 1959	Tanout, Africa	1.3×10^{-6} BO at 4750 Å and 2.6×10^{-7} BO at 8300 Å	8800	-
15 Feb. 1961	Bucuresti	11.7 lx at 4270 Å and 0.3 lx at 5270 Å	1.6	-
20 July 1963	61°25'N 117°30'W	0.98 kR/Å at 4278 Å	0.4	7400
	10.7 km	0.76 kR/Å at 4860 Å		
		0.41 kR/Å at 5577 Å		
		0.12 kR/Å at 6300 Å		
	New Portland, Me. 12.2 km and	4×10^{-10} BO for 4000-6500 Å	4.3	-
	35.6 km	0.1×10^{-10} BO for 4000-6500 Å	1.2	-

Table 35 (Contd.). Observed Sky Brightness During Some Total Solar Eclipses

Date	Site Observation and Elevation	Sky Brightness as Reported*	Equivalent Brightness at 5600 Å in kR/Å	Blackbody Temperature in °K
20 July 1963 (Contd.)	61°12'N & 116°28'W 9.2 km Herman, Me.	Solar depression of 5° 19.6 kR/Å at 5200 Å 3.5 kR/Å at 6200 Å	- 11.8	- -

*BO is the surface brightness of the sun.

Part 2

Sightings of Stars and Planets

3 MAY 1375 BC 1375 A

Nature 228, 651-652 (1970)
Ugarit, Syria

"The Sun went down (in the daytime) with Rashap (= Mars) in attendance." "Calculation shows that on the morning of 3 May 1385 , Mars was below the horizon. Both Aldebaran and Capella, however, were near the darkened Sun and either star may have been mistaken for Mars."

5 JUNE 346 346 A

Ginzel[30] p. 645
Campania

In the 20th year of the rule of Constantine: In that time in Campania, twelve cities were laid low by an earthquake; and so great was the eclipse of the sun, that the stars were seen at noon....

18 JUL 418 418 A

Ginzel p. 647
Byzantium

(It happened) that when Theodosius had entered upon the years of adolescence, and the month of July had advanced to the 19th (day), about the 8th hour of the day, the sun was eclipsed to such an extent that the stars shone, and drought followed upon these labors (of the sun), so that it caused everywhere the unaccustomed death of many men and other animals. But when the sun was eclipsed, a kind of gleam appeared in the sky, exhibiting the shape of a cone, which some people, through ignorance of the heavenly bodies, called a comet.... (Philostorgii Cappadocis Ecclesiasticae Historiae lib. XII, c. 8.)

18 JUL 418 418 BA

Ginzel p. 647

The sun was eclipsed in the 3rd hour of the 14th day before the Kalends of August, and a star appeared blazing from the east up to the Kalends of September. (Annales Esromenses.)

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30. Ginzel, F.K. (346) Akademie der Wissenschaftern. Vienna: Matematisch - Naturwissenschaftliche Klasse. Sitzungsberichte. 88:629-755 and 89:491-559. Translated by Linguistic Systems, Inc., Cambridge, Mass.

18 JUL 418
Ginzel p. 648

418 BB

The sun was eclipsed in the 3rd hour of the 14th day before the Kalends of August, and there appeared a star shining from the east up until September (Annales Chronographi vetusti.)

19 JUL 540
Ginzel p. 650
England

540 AA

In the year 540 an eclipse of the sun occurred on the 12th day before the Kalends of July, and the stars appeared almost half an hour from the third hour of the day (Epitome sive breviarium Bedae historiae ecclesiasticae.)

19 JUN 540
Ginzel p. 650
England

540 AB

In the 7th year of Hinricus the sun was obscured from the 3rd almost to the 9th (hour), so that the stars appeared. (Henrici archidiac. Huntinon. Hist. lib. II.)

19 JUN 540
Ginzel p. 650
England

540 AC

Again, after two years the sun was obscured for half an hour after the calculation of the 3rd (hour), so that the stars were perceived everywhere in the firmament. (Chron. Ethelwerdi lib. quat.)

19 JUN 540
Ginzel p. 650
Trier, France

540 B

An eclipse of the sun occurred 12 days before the Kalends of July, and the stars appeared almost half an hour from the third hour. (Annales S. Maximi Trevirensis.)

2 OCT 563
Ginzel p. 651
Clermont, France

563 A

For often three or four great bright lights appeared around the sun, which (lights) the peasants called suns, saying: Behold, three or four suns in the sky.

On a certain occasion, however, on the Kalends of October, the sun was so obscured that not even a fourth part remained shining at that time, but was seen appearing dark and discolored, like a sack-cloth. For also a star, which some call a comet, having a ray like a sword, appeared above that region for an entire year, and the sky seemed to burn, and many other portents appeared. (S.Gregorii Episcopi Turonensis Hist. Franc. lib. IVc, XXXI.)

4 OCT 693 693 AA
Ginzel p. 658
Byzantium

Emperor Justinian .... In the 9th year so great was the eclipse of the sun that the stars were seen. (Geogii Cedreni Comp. histor.)

4 OCT 693 693 AB
Ginzel p. 659
Byzantium

But in the 9th year of Justinian's rule .... In this year indeed an eclipse of the sun occurred in the 3rd hour of the day, so that certain bright stars were visible. (Theophanis Chronographia, -- Anastasii Hist. Eccl.)

4 OCT 693 693 B
Ginzel p. 659
Pavia, Italy

In the ninth year of Justinian's rule, an eclipse of the sun occurred in the 3rd hour of the day, so that certain bright stars appeared. (Hist. misc. Pauli Diac. lib. XIX.)

5 MAY 840 840 AA
Ginzel p. 663
France

An eclipse of the sun took place in the days of the Litanies, on the 3rd day before the Nones of May, on the 4th day of the week, about the 8th hour of the day, and remained almost half an hour; (it was) so dark that the stars appeared most brightly in the sky. (Annales Lugdunenses.)

5 MAY 840 840 AB
Ginzel p. 664
France

But in the vigil itself of the ascension of the Lord, that is, on the 4th day before the Ides of May, there occurred about the 7th and 8th hour of the day an eclipse of the sun, so powerful that the stars also were visible on account of the obscurity of the sun, and the color changed in things on earth. (Annales Francorum Metenses.)

5 MAY 840 840 AC
Ginzel p. 665
France

In this time an eclipse of the sun occurred, on the 3rd day of the great Litany, in an unusual way. For darkness prevailed to such an extent in the withdrawal of light that it seemed in no way to differ from real night. For indeed, the fixed order of the stars was thus perceived, that no star suffered the dulling effect of the sun's light, but rather the moon, which had shown itself opposite to it, gradually, as it proceeded toward the east, had restored the light to it (the sun) on the western side, contrary to its custom, when it is first or second perceived, and thus by increments the entire orb of the sun received its full beauty. (Vita Ludovici Pii.)

5 MAY 840 840 B
Ginzel p. 666
Germany

At that time, 7 days before the Ides of May, a terrible eclipse of the sun filled the minds of mortals with great horror. They say that that day was little different from night, that the stars were conspicuous in the sky, and the light of the moon was revealed especially visible, as if the heavenly bodies portended that soon the great light was to be removed from earth. (Baicae Gentis Annales.)

5 MAY 840 840 C
Ginzel p. 667
Belgium, Netherlands

On the 3rd of May ... in the 9th hour (there was) an eclipse of the sun, and the stars were seen conspicuous in the sky, just as in the time of night. (Ann. Xantenses.)

5 MAY 840 — 840 DA
Ginzel p. 668
Italy

This was an eclipse of the sun so awful and dark, that in the absence of light darkness reigned in an uncommon manner, and at the peak of day the stars appeared brightly. (Tatti Annali sacri della citta di Como.)

5 MAY 840 — 840 DB
Ginzel p. 668
Italy

In the third year of the indiction the sun was so obscured in this world, and the stars appeared in the sky, on the 3rd day before the Nones of May, in the ninth hour, in the Litanies of the Lord, for about half an hour. Great distress occurred; and when the people perceived this, many thought that this age would not last any longer; but while they were contemplating these perplexities, the sun shone again and, as if trembling, began to flee into what was previously darkness. (Andrae Bergomatis Chronicon.)

29 OCT 878 — 878 A
Ginzel p. 669
Iceland

On the 9th hour of the day the sun was so obscured that stars appeared in the sky. (Annales Islandorum regii)

29 OCT 878 — 878 BA
Ginzel p. 670
France

On the 4th day before the Kalends of November (there was) an eclipse of the sun, on the 4th day of the week, about the 8th hour of the day, and it lasted almost half an hour, so dark (was it) that the stars appeared most brightly. (Annales S. Benigni Divionensis.)

29 OCT 878 — 878 BB
Ginzel p. 670
France

On the 4th day before the Kalends of November, in the 9th hour of the office, (there was) a very great eclipse of the sun, so that the stars appeared, and the moon. (Petri bibliothecarii Hist. Franc. abbreviata.)

29 OCT 878 878 CA
Ginzel p. 671
Belgium

On the 4th day before the Kalends of November, there was an eclipse of the sun after the 9th hour of the day so dark that even stars appeared. (Annales Eli.nenses minores)

29 OCT 878 878 CB
Ginzel p. 671
Belgium

On the 9th hour of the day the sun was so obscured that stars appeared in the sky. (Chronicon Alberici)

29 OCT 878 878 DA
Ginzel p. 671
Germany, Switzerland

Sigebertus witnessed on the 9th hour of the day the sun was so obscured that stars appeared in the sky. (Menken. II, 470 [Erfurt])

29 OCT 878 878 DB
Ginzel p. 671
Germany, Switzerland

An eclipse of the moon occurred on the 3rd day before the Ides of the same month, in the last hour of the night. The sun also, on the 4th day before the Kalends of November, after the 7th hour, was so obscured for half an hour that the stars appeared in the sky, and everyone thought that night was imminent. (Ann. Franc. Fuldenses)

29 OCT 878 878 DC
Ginzel p. 672
Germany, Switzerland

The sun was eclipsed so that at the ninth hour of the day stars were seen. (Chronicon Engelhusii)

29 OCT 878 878 DD
Ginzel p. 672
Germany, Switzerland

In the 28th year of Gerungus the abbot .... In the aforesaid year the sun on the ninth hour of the day was so obscured that the stars were seen in the sky,

as if it had been in the middle of the night. (Joannis Trithemii Annales Hirsangienses.)

7 AUG 891 — 891 AA
Ginzel p. 673

While Leo was ruling for the second year, Angaco, Duke of Longobardia, son-in-law of the King of France, when he learned of the death of Basil, withdrew from the alliance of the Romans and claimed all sovereignty for himself. Against him Leo sent Constantine the patrician, prefect of the revenues, with the western armies. When battle had been joined, Constantine fell and scarcely escaped death himself, his army having been destroyed. About the same time, in the 6th hour of the day the sun was eclipsed to such an extent that the stars were seen. There arose also violent blasts of wind, lightning, terrible thunder and blazing thunderbolts, by which seven men were struck and perished in the forum on the steps of Holy Constantine .... (Cedrenus Historiar. Comp. II 595.)

7 AUG 891 — 891 AB
Ginzel p. 674

And so Leo, after his father had been removed from human affairs, ruled for 26 years. Since he wished to punish Santabarenus, he first undertook to get Photius out of the way, because he thought that he would zealously support Santabarenus. For a rumor had been spread to the effect that Photius, all but promising rule to one of his own people, for this very reason had communicated with Santabarenus; and that some treachery had been plotted against Leo. Therefore Leo first drove him into exile, and then, after he had been afflicted with other outrages, he at last deprived him of his eyes. There occurred at this time such a great eclipse of the sun about the 6th hour of the day, that even the stars themselves were seen. (Michaedis Glycae annales.)

7 AUG 891 — 891 AC
Ginzel p. 674

In the second year of the rule of Leo, when Longumbardia had been stirred to revolt, Constantine, the prefect of revenues, had been sent with all the legions. When battle had been joined, scarcely he alone was able to escape, the rest having been partly killed, partly captured. But indeed there occurred an eclipse of the sun, so that it was night through the 3rd hour, and the stars appeared. (Symconis magistri ac Logothetae annales.)

7 AUG 891 — 891 AD
Ginzel p. 674

So great was the sun diminished that at the 6th hour stars appeared in the sky. (Georgii monachi Vitae Imperatorum Recentiorum)

18 JUL 939 — 939 A
Ginzel p. 676
Italy

The sun was obscured and stars appeared at the beginning of the month of July, on the 3rd day of the month, the 3rd day of the holidays, the 3rd hour, the 29th moon. (Annales Lupi Barcensis protospatae.)

21 DEC 968 — 968 AA
Ginzel p. 677
Byzantium

Nichephorus Phocas emperor. On the 22nd day of December, the 3rd hour, there was such a great eclipse of the sun that the stars also appeared. (Cedrenus Histor. Comp.)

21 DEC 968 — 968 AB
Ginzel p. 677
Byzantium

The same Phocas was also marvellously afflicting the city while he was building the fortifications of the palace. He did this moreover because he feared the things which were commonly reported; for it had been proclaimed by an oracle that he would die in the palace. There happened at that time, around the 3rd hour of the day, such a great eclipse of the sun that even the stars themselves were seen. (Mich. Glycae annales.)

21 DEC 968 — 968 AC
Ginzel p. 678
Byzantium

While these things were done by the Emperor in Syria, at about the time of the winter solstice, there was an eclipse of the sun as there had never been before, except for that which in the passion of our Lord was brought upon the earth on account of the madness of the Jews, and they, blinded by this (eclipse) affixed the creator of the universe to the cross. The eclipse was of such a sort. It was the 22nd day of the month December; on the 4th hour of the day, with a clear sky, when darkness was poured upon the earth, and all the stars appeared more clearly.

Each could see the orb of the sun without brilliance, devoid as it was of light, and (one could see) an obscure and thin radiance, like a narrow band, shining around the furthest edges of the rim of the orb. Gradually indeed, the sun, outstripping the moon (for the latter appeared shining perpendicularly to it), sent forth its former rays and filled the earth again with light. Mankind, terrified by this strange and unusual spectacle, placated the deity, as was right, with prayers. (Lenonis Deaconi Caloensis Historiae libri decem.)

21 DEC 968 — 968 B
Ginzel p. 680

Four days before the Nones of September, the moon was changed to blood. On the same year also, in the month of June, a marvellous sign appeared in the sky, a snake indeed, great and headless. There followed immediately the death of Hugo the Great, Prince of the French, Burgundians, Britains, Britons, and Norsemen. An eclipse of the sun took place and the stars appeared from the first hour up to the third. (Chronicon Floriacense.)

20 OCT 990 — 990 A
Ginzel p. 553

Imp. Basilius .... Even the sun was missing in the middle of the day and stars were seen. (Cedrenus Hist. Comp.)

28 JUN 1033 — 1033 AA
Ginzel p. 683
France

1033. In this year an eclipse of the sun took place on the day of the festivity of the holy apostles Peter and Paul, the sixth day of the week, at mid-day, and a star was clearly seen. (Annales S. Benigni Divionensis.)

28 JUN 1033 — 1033 AB
Ginzel p. 683
France

.... on the 6th day of the week, the day of Peter and Paul, the 28th moon, there occurred an eclipse or failing of the sun from the 7th hour of the day up to the 9th, so that a more horrible thing was never perceived to have happened. For the very appearance of the sun seemed to have been fashioned in the manner of the moon which is fourth from its re-kindling. It was indeed perceived to be of a saffron hue. Everything under the heavens appeared to human sight to be of a saffron color. Behind and in front of the sun shown stars. (Annales Besuenses.)

1 AUG 1133 1133 AA
Ginzel p. 697
England

... For the sun on the 6th hour of the day was so obscured that it did not seem to be day as much as night; and stars were seen around the sun; indeed on the following day there occurred a great earthquake .... (Annales de Wintonia)

1 AUG 1133 1133 AB
Ginzel p. 698
England

There was a fearful eclipse on the 6th hour of the day and stars were seen. (Annales Prioratus de Wigornia.)

1 AUG 1133 1133 AC
Ginzel p. 698
England

For the sun in the sixth hour of the day covered its bright head with foul rust (as the poets are wont to say), striking the minds of men by its eclipse; and next, on the 6th day of the week, at dawn, there was such a great earthquake that the earth seemed to sink, after a horrible sound had first been heard under the earth. I saw stars around the sun during the eclipse, and I say that in the earthquake, the wall of the house in which I was sitting was raised by two movements and settled down with the third. (Willelmi monachi Malmesbur. Histor. novell. lib. I.)

1 AUG 1133 1133 BA
Ginzel p. 698
Belgium, Netherlands

On the 4th day before the Kalends of August, the 27th moon, at mid-day there occurred an eclipse of the sun for about half an hour, and stars were seen in the sky. (Anselmi Contin. Sigeberti.)

1 AUG 1133 1133 BB
Ginzel p. 698
Belgium, Netherlands

On the 4th day before the Nones of August, at mid-day the sun was so obscured that stars appeared. (Annales Floressienses.)

1 AUG 1133 1133 BC
Ginzel p. 698
Belgium, Netherlands

On the 4th day before the Nones of August there occurred an eclipse of the sun in a horrible fashion around noon, and the moon appeared facing the orb of the sun, and the stars flashed because of the greatness of the darkness. Men were struck with very great terror. (Annales S. Jacobi Leodiensis.)

1 AUG 1133 1133 BD
Ginzel p. 699
Belgium, Netherlands

In the same year on the 4th day before the Nones of August, on the 6th hour of the day the sun was obscured, not covered with clouds, but suffering its own eclipse, and so great was the darkness that day seemed to have been changed to night, and the stars appeared with no cloud blocking them just as in night.... (Annales Egmundani.)

1 AUG 1133 1133 BE
Ginzel p. 699
Belgium, Netherlands

On the 4th day before the Nones of August at noon, the sun was so obscured that stars appeared in the sky. (Annales Fassenses.)

1 AUG 1133 1133 BF
Ginzel p. 699
Belgium, Netherlands

The sun was obscured on the 4th day before the Nones of August, in the 6th hour, to such an extent that stars appeared in the sky. (Sigebert. Cotinuat. Burburgensis.)

1 AUG 1133 1133 C
Ginzel p. 700
Germany

The sun was obscured on the 4th day before the Nones of August at mid-day, and darkness appeared; the stars also shown, and the earth was wet with dew. (Annales S. Petri Erphesfurdenses.)

1 AUG 1133
Ginzel p. 700
Germany

1133 CA

An eclipse of the sun took place on the 4th day before the Nones of August at mid-day, and darkness appeared; the stars also shown, and the earth was wet with dew. (Chron. Vetero-Cellense minus.)

1 AUG 1133
Ginzel p. 700
Germany

1133 CB

An eclipse of the sun occurred on the 4th day before the Nones of August around the 6th hour, to such an extent that stars appeared in the sky. (Annales Hildeshemenses.)

1 AUG 1133
Ginzel p. 700
Germany

1133 CC

An eclipse of the sun occurred on the 4th day before the Nones of August, to such an extent that stars appeared. (Annales Palidenses.)

1 AUG 1133
Ginzel p. 700
Germany

1133 CD

In the year of our Lord 1133, in the 11th year of the indiction, at the beginning of the 12th epact, in the 13th year of the lunar cycle, on the 4th day before the Nones of August, on the 27th moon, at mid-day, there occurred such a dark eclipse of the sun that it was almost like night, and several stars were seen. (Notae Corbeienses.)

1 AUG 1133
Ginzel p. 701
Germany

1133 CE

The sun was obscured on the 4th day before the Nones of August at mid-day, and darkness appeared; the stars also shown and the earth was wet with dew. (Annales Aquenses.)

1 AUG 1133
Ginzel p. 701
Germany

1133 CF

Darkness appeared, and the sun was obscured in its entire orb around mid-day for almost an entire hour of the day, and the 17th moon appeared, on the 4th

day before the Nones of August. For then stars appeared as if it were night, and the birds of the sky flew away, and the earth was wet with dew, and all men were filled with great panic, thinking that the last day had come . . . (Annales Rodenses.)

1 AUG 1133 — 1133 CG
Ginzel p. 701
Germany

On the 6th hour of the day, the day was obscured, and stars appeared. (Annales Brunwilarenses.)

1 AUG 1133 — 1133 CH
Ginzel p. 702
Germany

In this year, on the 4th day before the Nones of August, at about the 9th hour of the day there occurred such a great eclipse of the sun that stars could be seen in the sky. (Mariani Scotti Chron. Contin. I.)

1 AUG 1133 — 1133 CI
Ginzel p. 702
Germany

In the same year an eclipse of the sun occurred on the 4th day before the Nones of August, at mid-day, and so great was the darkness that stars appeared through the whole earth as if it were the middle of the night. (Annales Herbipolenses.)

1 AUG 1133 — 1133 CJ
Ginzel p. 702
Germany

In the same year, on the 4th day before the Nones of August, in the 27th moon, the sun was obscured in the 7th hour of the day, and darkness appeared, to such an extent that stars appeared in the sky. (Annales Sancti Disibodi.)

1 AUG 1133 — 1133 CK
Ginzel p. 702
Germany

In the 13th year of the 19-year cycle, when Liutherius the Pious emperor was holding the reins of government, on the 4th day before the Nones of August, on the 4th day of the week, as it was approaching the 9th hour, the sun in one moment became black as pitch, the day was changed to night, stars were seen in vast

numbers, the state of the world appeared as it does at night, and rivers of water were said to have strayed from their course.... (Annales Halesbrunnenses.)

1 AUG 1133 — 1133 CL
Ginzel p. 702
Germany

That famous eclipse of the sun was on the 4th day before the Nones of August around mid-day, at the 27th moon, in the 13th year of the 19-year cycle. After mid-day, between the 7th and 8th hour there was seen an eclipse of the sun in Leo, except that there was no prodigy and no portent in the sun. For physicists say that an eclipse of the sun does not take place except in the last or in the first moon, but now it was in neither of those. For rather, in the 27th moon, when the 28th and 29th still remained, very many stars were seen next to the sun, the hearts of many were stung, as they despaired of the light (of the sun), the sun lay entirely hidden, as if it did not exist, for about a half an hour it was like night, and the appearance of the world was wretched, horrible, black, and amazing. (Magni Presbyteri Annales Reichersergenses.)

1 AUG 1133 — 1133 CM
Ginzel p. 703
Germany

In this year, on the 4th day before the Nones of August, in the 27th moon, around noon, when the day was clear, darkness appeared so that the stars shown. (Annales S. Stephani Frisingensis.)

1 AUG 1133 — 1133 CN
Ginzel p. 704
Germany

In the aforesaid year, on the 4th day before the Nones of August, on the 22nd moon, in the 6th hour of the day, there occurred a great failing of the sun, which the Greek call an eclipse, to such an extent that stars were clearly seen to appear in the sky. Then there followed a great unevenness of the air and many a rain-storm. (Annales Hirsang.)

1 AUG 1133 — 1133 D
Ginzel p. 704
Austria

In this year, on the 4th day before the Nones of August around mid-day there occurred an eclipse, i.e. a failing, of the sun; so great was it that stars shown

and darkness appeared for one hour throughout the whole earth. (Chron. monnast. Admont.)

20 MAR 1140
Ginzel p. 707
England

1140 AA

And in this year an eclipse of the sun occurred on the 13th day before the Kalends of April, in the middle of the 9th hour, and it remained almost for the space of an hour, and very many stars appeared around the sun. (Annales de Bermundenscia.)

20 MAR 1140
Ginzel p. 707
England

1140 AB

It was granted to the monks of the abbey of Sarum that they should have privileges and abbots. An eclipse of the sun occurred, and stars were seen around the sun. (Annales de Wintonia.)

20 MAR 1140
Ginzel p. 707
England

1140 AC

In the Quadragesima (i.e. Lent), on the 13th day before the Kalends of April, in the 9th hour, the 4th day of the week, an eclipse of the sun occurred, as men were sitting down to table, and they were terrified by excessive mental anxiety. But, after they learned of the affair, they went outside and beheld stars around the sun. (Annales de Margan.)

20 MAR 1140
Ginzel 1. 707
England

1140 AD

In this year, in the Quadragesima, on the 13th day before the Kalends of April, there was an eclipse of the sun throughout the whole of England, as I have heard. In our land, at any rate, and in the land of all our neighbors, there was a failing of the sun in such a noteworthy fashion that men (a thing which then happened practically everywhere), as they were setting down to table, first feared ancient Chaos; presently, when the event had been ascertained, they went forth and perceived stars around the sun. (Willelmi moanci Malmesbur. Hist. nov. lib. II.)

25 OCT 1147
Ginzel p. 710
Belgium, Netherlands

1147 A

An eclipse of the sun occurred around the third hour of the day, on the 7th day before the Kalends of November. And when the solar light had not yet been restored to its purity but was still surrounded with an ecliptic mist, many beheld a conspicuous star in the sky. There were also others, who said that they had seen in the very orb of the sun the divine majesty, in such a way as it is often depicted by painters in books. (Continuatio Gemblac. Sigeb. Chron.)

3 SEP 1187
Ginzel p. 719
Denmark, Sweden

1187 A

On the day before the Nones of September, there occurred such a great eclipse of the sun, as the moon went under its orb, that the heavenly stars during the day flashed just as at night. The annales, which Langius reported to me, note this eclipse, which was mentioned by Gerardus Mercator and Vincentius. (Hamsfortii Chronol. secunda.)

3 SEPT 1187
Ginzel p. 721
Austria, Poland

1187 B

An eclipse of the sun occurred at mid-day, and stars were seen. (Continuatio Cremifanensis.)

3 SEPT 1187
Ginzel p. 721
Italy

1187 CA

In the same year, on the 4th of September, Ascalon was captured by the Turks. On the same day there was a partial eclipse of the sun in the 18th station of Virgo, and for the duration of two hours stars also appeared, as if the day were night. (Chron. Francisci Pipini Bononiensis.)

3 SEPT 1187
Ginzel p. 721
Italy

1187 CB

In the following year (1187), at that time, during the day, the stars were seen in the sky, the sky was obscured, and the sun was covered with darkness.... (Ludovici Cavitelli Cremon. Annales.)

22 JUN 1191 — 1191 A
Ginzel p. 722
England

In the month of June, on the Lord's day, in the vigil of the nativity of Saint John the Baptist, on the 9th day before the Kalends of July, on the 27th moon, in the 9th hour of the day, the sun suffered an eclipse and it lasted for three hours; so that the sun was obscured, and darkness appeared over the earth, and stars shone in the sky, and, when the eclipse had withdrawn, the sun returned to its former beauty. (Chronica Magistri Rogeri de Horeden.)

6 OCT 1241 — 1241 A
Ginzel p. 731
Germany

But in 1241 a. d. - some reckon two (years) less - on the second day before the Nones of October, on Sunday, our annals record that there was so great an eclipse of the sun, immediately at mid-day, that the stars were seen here in the sky quite horribly, just as in deep night. (Achill. Pirm. Gassari Annales Augsburgensis.)

24 MAY 1267 — 1267 A
Ginzel p. 737
Constantinople

(Mich. Palaeologus.) round this time the moon obscured the sun, when the latter was going through the fourth part of Gemini, about the third hour before noon, on the 25th day of May, 1267 a. d. The entire eclipse was of almost 12 points (Greek digits). But so great a darkness appeared about the earth around the middle time of that eclipse that many stars were visible.... (Niceph. Gregor. Hist. Byzant. Lib. IV c. VIII.)

6 JUN 1415 — 1415 A
Ginzel p. 754
Austria, Polar

In the same year as above, on the sixth day of the week, after Corpus Christi, at the hour of tierce, there was such a remarkable eclipse of the sun that the birds, terrified by the sudden darkness, fell to the earth. And the stars shone just as at night. (Math. de Michova Chron. Polonorum, lib. IV c. LI.)

13 SEPT 1699 — 1699 A
Phil. Trans. 22, 622-624 (1700)
Nurenburg
J. P. Worzelbaur

"Though the sky was free from clouds, yet no stars were visible. Nor was Venus itself visible in the open air, unless by some more sharp-sighted than ordinary." "However, we cannot learn that any star besides that of Venus was discovered by those who were spectators of it in the open air."

12 MAY 1706 — 1706 A
Phil. Trans 25, 2241-2243 (1706)
Letter written from Geneva, Switzerland
by J. Chr. Facio Duillier

"Some gentlewomen being in the country, did tell, as is said, more than sixteen stars. And many people, which were on the neighboring mountains, did see the sky starry in some places where it was not overcast as during the night in the time of the full moon."

12 MAY 1706 — 1706 B
Phil Trans. 25, 2244 (1706)
Marseilles, France
Mon. Chazelles and Father Laval

"Three stars were distincly seen, and during three minutes it was not possible to read."

12 MAY 1706 — 1706 C
France: Bureau des Long. Ann. p. 625 (1842)
Plantada and Clapies

"Pendant l'eclipse de 1706, Plantade et Clapies virent, à l'oeil nu, Venus, Mercure, Saturne, Aldebaran, et d'autres étoiles qui ne sont pas nommées."
During the eclipse of 1706, Plantade and Clapies saw, with the naked eye, Venus, Mercury, Saturn, Aldebaran, and other stars which were not named.

22 APR 1715 — 1715 A
Phil Trans 20, 316 (1715)
Upsala, Sweden

"And besides Jupiter, Mercury, and Venus, of the fixt stars Cassiopea, Capella, Oculus Tauri, and Orion (Sirius not being yet risen) were visible."

22 APR 1715 1715 B
Phil. Trans. 20, 249-250 (1715)
London, England
Dr. Edmund Halley

"The three planets, Jupiter, Mercury, and Venus were all that were seen by the Gentlemen of the Society from the top of their house, where they had a free horizon: and I do not hear that any one in town saw more than Capella and Aldebaran of the Fixed Stars." "The darkness being more perfect in those places near which the center of the shade passed, where many more stars were seen, and in some not less than twenty."

22 APR 1715 1715 C
France: Bureau des Long. Ann. p. 626 (1842)
Louville

"Louville dit que pendant l'eclipse totale de 1715 on ne voyait pas assez clair pour lire, quoiqu'on distinguat les lignes de l'écriture. Il apercut quelques étoiles de seconde grandeur."

Louiville said that during the total eclipse of 1715 one was not able to see clear enough to read, although one could distinguish lines of writing. He caught sight of several stars of the second magnitude.

22 MAY 1724 1724 A
Observ. 15, 263 (1892)
2 Miles Northeast of Amesbury, England
Dr. Stukeley

"Venus was seen very plainly, but no other star.

22 MAY 1724 1724 B
Observ. 15, 264 (1892)
Paris, France
Maraldi, Cassini, and the brothers Delisle

"Notwithstanding scattered clouds, Mercury was distinctly seen between the sun and Venus, besides several fixed stars, including Capella."

24 JUN 1778 1778 A
Phil. Trans. 69, 110 (1779)
Ship between Azores and Cape St. Vincents
Don Ulloa

"For four or five seconds before the appearance of the shining ring, and during as many after it had disappeared, one could see stars of the first and second magnitude as at the entrance of night; but when it was in its greatest degree of brilliancy, only three of the first magnitude could be discovered.

16 JUN 1806 — 1806 A

Trans. Amer. Phil. Soc. 6 (old series), 267 (1809)
Kinderhook, N. Y.
J.J. de Ferrer

"The sky was very clear, not a single cloud was visible. Five or six principal stars and planets were visible."

16 JUN 1806 — 1806 B

Mem. Amer. Acad. Arts & Sciences 3, 20 (1809)
Salem
Nathaniel Bowditch

"The degree of light can be estimated by the number of stars visible to the naked eye. Those I took notice of were Capella, Aldebaran, Sirius, Procyon, the three bright stars in the belt of Orion, and the star α in its shoulder. Venus and Mars were also visible."

27 JULY 1832 — 1832 A

The Observatory 19, 307 (1896)
Great Cayman Island

"When the darkness was complete... the stars shone clearly as on a moonlight night..."

30 NOV 1834 — 1834 A

Amer. Jour. of Sci. 42, 175 (1842)
Beaufort, South Carolina

"In Beaufort S.C., 30 Nov 1834, only two planets and four stars of the first magnitude were seen, though one of them, Antares, was then only six degrees from the sun."

8 JUL 1842 — 1842A-1842B-1842C-1842D 1842E-1842F-1842G-1842H

France: Bureau Long. Annuaire. p. 279-281(1846)
A) Venice B) Perpignan C) On the sea shore
D) Narbonne E)Montpellier F) Digne G) Lodi H) Novare
Collected by M. Arago

A) "L'observateur de Venise ne cite, parmi les étoiles qui furent visibles dans cette ville, que la Chevre et Aldebaran."

The observer at Venice mentioned among the stars which were visible in that village, nothing but Capella and Aldebaran.

B) "Les curieux qui, à Perpignan, purent donner une attention suffisante à la recherche des étoiles, en apercurent quatre à cinq à l'oeil nu."

The curious who, at Perpignan, were able to give sufficient attention to the search for stars, caught sight of four to five with the naked eye.

C) "Au bord de la mer, quelques personnes en virent sept, d'autre dix. D'après les positions indiquées, it ne parait pas que Mars ait été un des astres visibles."

On the sea shore, several persons saw seven, others ten. After the positions were indicated, it did not appear that Mars was one of the heavenly bodies visible.

D) "MM. Pinaud et Boisgiraud parlent de quatre à cinq étoiles apercues à Narbonne, pendant l'eclipse totale, vers le zenith et du coté du couchant. Divers observateurs assurerent en avoir compte jusqu'à dix."

Misters Pinaud and Boisgiraud spoke of 4 to 5 stars perceived at Narbonne, during the total eclipse, toward the zenith and in the direction of the sunset. Various observers assured that they counted up to ten.

E) "Les personnes de Montpellier, à qui M. l'abbé Peytal demanda combien elles avaient apercu d'étoiles, repondirent que le nombre de ces astres visibles à l'oeil nu ne s'éléva pas au dela de cinq."

People of Montpellier, of whom Father Peytal asked several to look for stars, responded that the number of heavenly bodies visible to the naked eye was not more than five.

F) "A Digne, M. Dien vit à l'oeil nu, la Chèvre, β et ζ de Taureau, γ d'Orion. Des vapeurs couvraient une grande partie du ciel."

At Digne Mr. Dien saw with the naked eye, Capella, β and ζ Tauri, γ d'Orionis. Haze covered a large part of the sky.

G) "M. Piloa, à Lodi, apercut pendant l'obscurité totale: Mars, deus étoiles des Gemeaux, Aldebaran, la Chèvre, d'autres étoiles de première grandeur (on ne dit pas lesquelles).

Mr. Piola, at Lodi, saw during the total darkness: Mars, two stars of Gemini, Aldebaran, Capella, other stars of the first magnitude (he did not say which).

H) "M. Majoochi rapporte qu'à Novare, on ne vit, pendant l'obscurité totale, que Mars, la Chèvre et Aldebaran."

Mr. Majoochi reported that at Novare no one saw during the total eclipse anything but Mars, Capella and Aldebaran.

21 DEC 1843 — 1843 A
Roy Astr. Soc. 15, 173 (1846)
Parratt
John Caldecott

"Venus, Saturn, and Arcturus were plainly seen by my servants whom I had stationed to watch for stars."

18 JUL 1860 — 1860 D
Amer. Jour. of Sci. 80, 292 (1860)
Mount Saint-Michel, Palmas, Spain
A. Secchi

"Without seeking I saw Jupiter, Venus, and some other luminaries."

18 JUL 1860 1860 E
Roy. Soc. of Lond. Proc. 12, 62 (1862)
Rivabellosa, Spain
Warren de La Rue

"Jupiter and Venus were the only objects the author had time to identify, but some neighboring observers saw also Castor."

18 JUL 1860 1860 G
Memoirs of the Roy. Astr. Soc. 41, 178-179 (1879)
Vitoria
Martin Saar

"Four planets seen; Jupiter five minutes before totality. Also eight stars one of the third magnitude."

"Jupiter, Venus, Saturn, Mercury, Castor, Pollux, Regulus, Capella, β Aurigae, Procyon, β Canis Minoris, γ Leonis."

18 AUG 1868 1868 B
Phil. Trans. 169, 147 (1878)
Siam
Sir Harry St. George Ord

"The face of the sky was studded with stars as in deep twilight."

18 AUG 1868 1868 C
Roy. Soc. of Lond Proc. 17, 87 (1868)
Barram Point, Borneo
J. Pope Hennessy

"Those who were looking for stars counted nine visible to the naked eye. One planet (Venus?) was very brilliant."

18 AUG 1868 1868 F
Memoirs of the Roy. Astr. Soc. 41, 179 (1879)
Mantawalu Kiki, Celebes
Lieut. Anson

"At the instant of totality β Leonis and Regulus made their appearance simultaneously, but they both disappeared with the first glimpse of the returning bright rays. No other heavenly bodies were observed by me."

18 AUG 1868 1868 G
Astronomische Nachrichten 77, 186 (1871)
Edmund Weiss

"... during totality 3 stars were seen."

7 AUG 1869 1869 A
Memoirs of the Roy. Astr. Soc. 41, 179-180 (1879)
Mattoon, Illinois
President Hill

"Venus appeared a minute or two before the total obscuration. At the instant of total obscuration Mercury, Arcturus and Vega appeared. We looked sharply for Capella, Procyon, Castor and Pollux, Regulus, and Altair, and also looked less carefully for Saturn, Antares, Spica, and Mars, and we saw nothing either with the naked eye or our opera glasses beyond the two stars and two planets already mentioned."

7 AUG 1869 1869 CB
Pub. of the U.S. Naval Obs. Appendix II, 107-108 (1869)
Des Moines, Iowa
Professor Eastman

"At 6^h32^m saw Saturn and Antares, and at 6^h35^m saw second-magnitude stars."

7 AUG 1869 1869 CC
Pub. of the U.S. Naval Obs. Appendix II, 134 (1869)
Des Moines, Iowa
Dr. Curtis

"Glancing at the surrounding sky, I observed two stars, probably Venus and Mercury, though I made no note of their position."

7 AUG 1869 1869 D
Memoirs of the Roy. Astr. Soc. 41, 180 (1879)
Bristol, Tennessee
Mr. F.W. Perkins

"Mercury, Venus, and Saturn were visible; but I looked in vain for stars in any of the northern constellations."

7 AUG 1869 1869 E
Memoirs of the Roy. Astr. Soc. 41, 179 (1879)
Springfield, Illinois
Mr. Charles A. Schott

"During totality the following heavenly bodies were seen: - Mercury, Venus, Saturn, Arcturus, Vega, Antares, Altair, and Benetnasch. Some claim to have seen more, but the above are all that were recognized by the observers."

7 AUG 1869 1869 G
Pub. of the U.S. Naval Obs. Appendix II, 22 (1869)
Oakland Station, Kentucky
J.A. Timmons, J.L. Donaldson, J.M. Younglove

"The stars were plainly visible with the naked eye."

7 AUG 1869 1869 H
Pub. of the U.S. Naval Obs. Appendix II, 181 (1869)
W.S. Gilman Jr.

"Of the planets and stars I saw but Venus, Regulus, and Mercury. I saw Regulus with difficulty as a glimpse star, with the unaided eye. The report shows that seven stars were witnessed by our party if we include the little brilliant below the sun."

7 AUG 1869 1869 I
Pub. of the U.S. Naval Obs. Appendix II, 190 (1869)
36°35' N. 82°9' W
F.W. Bardwell

"Mercury seemed to shine with the full light of a star of the first magnitude, and Venus very much brighter, while Regulus, which is classed as nearly of the first magnitude, appeared scarcely as bright as one of the second class, but it remained visible several seconds after the reappearance of the sun's rays."

7 AUG 1869 1869 J
Pub. of the U.S. Naval Obs. Appendix II, 195-196 (1869)
White Top Mountain, Virginia
A.J. Myer

"A very cursory examination only could be given the stars and planets visible during the totality, as in a clear twilight at evening. Venus and Mercury, near the apparent place of the sun, exhibited an unexpected brilliancy. Colonel Winthrop was impressed with the number of stars visible here and elsewhere in the heavens, and not confined to those of the first magnitude only, as by far greater than he had been led to anticipate by descriptions of previous eclipses."

7 AUG 1869 1869 K
Pub. of the U.S. Naval Obs. Appendix, 202 (1869)
Plover Bay, Siberia
S.R. Franklin

"There was but one star (Mercury) visible, owing to the overcast condition of the sky."

22 DEC 1870 — 1870 A
Nature 3, 195 (1871)
San Antonio Lat 36°37' N. Long. 24' W.
Rev. S.J. Perry

"Venus alone was visible."

22 DEC 1870 — 1870 CB
Washington Observations for 1869 Appendix I, 11 (1871)
Gibraltar
Prof. Newcomb

"But, after finishing my observations, Mr. Sprague and Mrs. Newcomb, both of whom were outside of my tent, agreed in testifying that the sky in the direction of the sun seemed quite free from clouds during the entire total phase, and that two stars were distinctly visible in the neighborhood of the sun."

6 APR 1875 — 1875 A
Phil. Trans. 169, 147 (1878)
Bangkok, Siam
J.N. Lockyer & A. Schuster

"During this last eclipse several persons both at the observatory and in Bangkok were looking out for stars, and more than four could in no case be seen."

29 JUL 1878 — 1878 B
Scientific American 39, 113 (1878)
Denver, Colorado
Maria Mitchell

"Mercury, Regulus and Mars were seen, Venus was very brilliant, Procyon and several other stars were visible."

11 JAN 1880 — 1880 A
Observ. 3, 391 (1880)
Santa-Lucia
George Davidson

"Jupiter and Mars were seen but no stars."

17 MAY 1882 — 1882 A
Proc. Roy Soc (Edinburgh) 11, 830 (1882)
Sohag, Egypt
J. Buchanan

"During totality the stars shown out brightly."

6 MAY 1883 1883 A
Amer. Assoc. for the Advancement of Science p. 76(1883)
Caroline Island
Edward S. Holden

"Mr. Holden's search continued during the whole of totality (five minutes and twenty-five seconds), with a six inch telescope with a power of 44 and field of 57' in declination. He saw every star on the map he had previously published in Science (23 Feb 1883), down to the sixth magnitude, inclusive, except the three sixth magnitude stars nearest to the sun; and he saw only these stars."

9 SEPT 1885 1885 C
Trans. Roy. Soc. New Zealand 18, 378 (1885)
Woodstock, Stoke, New Zealand
J. Meeson

"During the obscuration, stars were plainly seen by those whose attention was not already bespoken by something more unusual. I saw Jupiter very distinctly."

28-29 AUG 1886 1886 B
Phil Trans. 180A, 384 (1889)
Grenada
Robert H. Archer

"On a cloud passing over towards the end of totality I looked at the stars overhead, but there were so many in sight that I could not pick out what they were; I should say that, judging by the contrasts between their brightness, some of them must have been of the third or fourth magnitude."

28-29 AUG 1886 1886 D
Phil Trans. 187A, 599 (1896)
West Indies
J. Lockyer

"During the eclipse of 1886 the sun itself was clouded over, as seen from the station occupied by myself in the West Indies; but in other parts of the sky a great number of stars were visible - a much greater number than is visible at full moon."

19 AUG 1887 1887 A
Sid. Mess. 7, 1 (1888)
Steglitz, Germany

"α Persei, a star of the second magnitude, was visible in the zenith."

19 AUG 1887 — 1887 G
Sid. Mess. 7, 163 (1888)
Mount Blaghodat, Russia
Dr. B. Von Englehardt

"There was no time to count the stars visible to the naked eye in the immediate neighborhood of the sun. Still Venus was seen on the left, and Mercury and Mars upon the right of the sun. Besides, the star α Leonis was visible almost in the rays of the corona."

19 AUG 1887 — 1887 I
Sid. Mess. 7, 5 (1888)
Elpatievo Narishkine
Mr. Il. Urech

"Regulus and Mercury shone brightly."

1 JAN 1889 — 1889 A1
Sid. Mess. 8, 169 (1889)
Liegan, California
W. T. Coffin

"I saw several stars in the vicinity of the eclipse twinkling brightly; and, on looking overhead eastward and northward, saw many more, but I was too much occupied in sketching the corona to take any note of them."

16 APR 1893 — 1893 B
Phil Trans 187 A, 599 (1896)
Fundium, Senegal
Mr. Fowler

"At the African station in 1893, the corona was so bright that only the planets Jupiter and Venus were seen by Mr. Fowler."

9 AUG 1896 — 1896 A
Observ. 19, 347 (1896)
Orlovski, Russia
Prof. Belopolsky, Mr. Orbinsky & Mr. Vittram

"Several stars of the first magnitude were visible."

9 AUG 1896 — 1896 B
Observ. 19, 348 (1896)
Bodo
John Dover

"I glanced away from my telescope for a moment to see if any stars were visible, and observed Jupiter and Venus. Mercury and Regulus were also seen by others present."

9 AUG 1896 1896 C
Observ. 19, 349 (1896)
Aboard the S. S. 'Ohio' American Line
Miss Mary Proctor

"The planets Jupiter, Mercury, and Venus were plainly seen during totality, and many well known constellations."

22 JAN 1898 1898 A
Observ. 21, 118 (1898)
Viziadrug, India
From the "Times of India"

"To the southward Venus shone with the brilliance of a tropical night; below her Mars less clearly, and three stars of lesser magnitude were barely visible."

22 JAN 1898 1898 B
Observ. 21, 119 (1898)
Jeur, India
A Lady's Account

"I saw 2 stars only: Venus, I suppose, was one."

22 JAN 1898 1898 C
Observ. 21, 120 (1989)
Talni, India
From the "Daily Graphic"

"Mars further away still in the same direction, and two or perhaps three stars could also be detected, though fainter far than Venus."

22 JAN 1898 1898 D
Observ. 21, 85 (1898)
Bombay, India

"One naturally expected stars to peep out and twinkle in semi-darkness. But the scene here was too bright for that."

28 MAY 1900 1900 A
Observ. 23, 247 (1900)
Ovar
Greenwich Expedition

"Venus and Mercury were seen, but no stars were obvious except Sirius."

28 MAY 1900 1900 B
Observ. 23, 280 (1900)
Elche, Spain
Prof. M. Moye

"No star except Sirius was seen, but Mercury was as bright as Venus at the beginning of the twilight, and it is needless to say that Venus was dazzling over our heads."

28 MAY 1900 1900 CA
Astrophys. Jour. 12, 94 (1900)
Juliette, Georgia
C.W. Crockett

"Mercury was seen. Some of the party said that another heavenly body was visible."

28 MAY 1900 1900 CB
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D161 (1905)
Juliette, Georgia

"There were no stars seen, Mercury alone being visible. The attention of the observers was directed toward the sun, so that stars may not have been noticed, although bright enough to be seen."

28 MAY 1900 1900 D
Astrophys. Jour. 12, 101 (1900)
Norfolk, Virginia
Mrs. Fressenden

"Mrs. Fressenden saw the planet Mercury but no stars."

28 MAY 1900 1900 G
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D82 (1905)
Barnesville, Georgia
Prof. O. Ashmore

"During totality the planet Mercury was distinctly seen near the Sun, and I was surprised at its brilliancy. Two or three stars were seen incidentally, though I was engaged with other observations."

28 MAY 1900 1900 H
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D167 (1905)
Washington, Georgia

"Mercury was very brilliant, much brighter than Venus at her best, perhaps 100 per cent brighter. α Tauri not seen. Venus was seen brilliant low down in the east for about five minutes after totality ended."

17 MAY 1901 — 1901 BA
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D210 (1905)
Solok, Sumatra
Professors Barnard and Skinner

"Professors Barnard and Skinner both noted that Venus and Mercury were plainly visible to the naked eye during totality."

30 AUG 1905 — 1905 B
Observ. 28, 355 (1905)
Guelma, Algeria
M. Trepied

"Mercury, Venus and Regulus being seen as soon as the light began to fail."

30 AUG 1905 — 1905 C
Observ. 28, 381 (1905)
Alcala de Chisvert, Spain
Prof. M. Moye

"Owing to the general illumination, decidedly lighter than a full moon night, I was unable to see any star or planet, with the exception only of Venus."

30 AUG 1905 — 1905 E
Observ. 28, 378 (1905)
Oriental Steamer 'Ortona' in the Med. near the Spanish Coast
Prof. J. Larmor

"The lightness of the eclipse was marked and disappointing, but Venus and Regulus were seen."

30 AUG 1905 — 1905 F
Observ. 28, 377 (1905)
Burgos, Spain
Mr. E.D. Benson

"Mercury and Venus were visible, but general observations of stars were impossible owing to clouds in the sky."

30 AUG 1905 — 1905 H
Pub. of the U.S. Naval Obs. Vol X, Part II, Appendix, B173 (1924)
Porta Coeli, Spain
Chaplain J.M. Bellows

"The stars came out one by one, and Venus shone resplendent as on a summer night."

30 AUG 1905 — 1905 I

Pub. of the U.S. Naval Obs. Vol X, Part II, Appendix, B177 (1924)
On the U.S.S. Minneapolis off Capricorn, Spain
Capt. J.M. Miller

"$1^h8^m10^s$ p.m. Planet Venus and star showing to westward."

3 JAN 1908 — 1908 A

Nature 78, 9 (1908)
Flint Island

"Mercury and Venus were seen, the former to the south-west and the latter to the north-east of the sun. Very few stars were observed."

28 APR 1911 — 1911 B

Nature 86, 568 (1911)
On board ss. Tofua, Pacific Ocean
Captain Halford

"... a great number of stars were logged."

17 APR 1912 (annular) — 1912 B1

The Observatory 35, 193 (1912)
St. Germain-en-Laye, France

"Mercury, which was seen near the Sun, and Venus, which was 20° distant, were seen at time of greatest phase."

17 APR 1912 (annular) — 1912 C1

Nature 89, 193 (1912)
Olhomarinho, Portugal
Mr. Butler and Mr. Dean

"Both Mercury and Venus, but no stars were visible."

17 APR 1912 (annular) — 1912 F1

Astronomie 26, 248 (1912)
Paris, France
G. Renaudot

"A 12^h5^m ... Vénus est bien visible à l'Ouest du Soleil.
A $12^h10^m30^s$, phase maximum ...
A 12^h15^m .... Je cesse de voir Vénus."
At 12^h5^m... Venus is easily visible to the west of the sun.
At $12^h10^m30^s$, maximum phase ...
At 12^h15^m... I cease to see Venus

21 AUG 1914 — 1914 B
Observ. 37, 383 (1914)
Minsk, Russia
H. S. Jones

"Regulus was seen shining through it [corona], and Mercury and Venus were also visible."

21 AUG 1914 — 1914 C
Nature 94, 203 (1914)
Hernösand, Sweden
A. L. Cortie

"For certainly it was a magnificent spectacle, enhanced by the appearance of the planet Mercury brilliantly shining to the north-west limb of the sun, and Venus near the south-east horizon."

8 JUN 1918 — 1918 C
Pub. of the U. S. Naval Obs. Vol X, Part II, Appendix, B217 (1924)
On the U. S. S. Dixie off Bona, Algeria
Lt. J. S. Doddridge

"A lookout was kept for stars and planets when first seen and noted as follows:

Name	Greenwich Mean Time h m s
Venus	1 0 0
Castor	1 15 0
Pollux	1 15 0
Regulus	1 25 0

21 SEPT 1922 — 1922 A
Nature 111, 441 (1923)
Stanthorpe, Queensland
Mr. J. C. Russell

"A few stars were seen during totality, but they were not specified. An account in B. A. A. Journ. (Jan) by Dr. A. F. Turner states that six were seen, of shich Venus, Mercury, Jupiter, and Spica were identified; two that were seen far to the south may have been α and β Centauri."

21 SEPT 1922 — 1922 B
Nature 111, 128 (1923)
Wallal, Australia
J. Hargreaves & G. S. Clark-Maxwell

"But in 1922 the stars were too faint to be photographed with a ratio of aperture to focal length 1/57."

10 SEPT 1923 1923 B
Pub. of the U.S. Naval Obs. Vol X, Part II, Appendix, B415 (1924)
Airplane at 12,000 ft.
Lt. B. H. Wyatt

"Also at about 1 o'clock at a distance of about 3 Moon's diameters, I noticed a star, which was visible only a few moments."

24 JAN 1925 1925 B
Pop. Astr. 33, 216 (1925)
Saugerties, N. Y.
R. E. Wilson

"Venus, Jupiter and Mercury showed up very well and two of the brighter stars, but there was too much light for the others."

24 JAN 1925 1925 C
Pop. Astr. 33, 218 (1925)
Guilford, Conn.
H. G. Blatchley

"The darkness fell but the snow covered ground kept it from getting very dark. However, Jupiter, Venus, Mercury, Vega, Alpha Aquilae and Epsilon Cygni were easily seen, and some other faint stars were visible but not identified."

24 JAN 1925 1925 D
Pop. Astr. 33, 232 (1925)
Poughkeepsie, N. Y.
Sebastian Albrecht's Son

"Although the 1925 eclipse will go down in history as a "light" eclipse, my son saw eight stars."

24 JAN 1925 1925 E
Pop Astr. 33, 184 (1925)
Windsor, Conn.
Alice H. Farnsworth

"Probably no one failed to see the group of three planets west of the sun. Several observers saw Saturn in the southwest. Among the stars, Vega, Altair and Deneb were identified and two observers reported seing 6 stars besides the group of three planets."

24 JAN 1925 1925 F
Pop. Astr. 33, 279 (1925)
North Scituate, R.I.
F.E. Seagrave

"Venus, Jupiter, Mercury, Vega, and Altair, all became visible to the naked eye."

24 JAN 1925 1925 G
Pop. Astr. 33, 190 (1925)
Mt. Beacon, N. Y.
Mrs. Isabel M. Lewis

"No stars were observed, but the three planets shone magnificently during totality."

24 JAN 1925 1925 H
Pop. Astr. 33, 355 (1925)
New Haven, Conn.
L. J. Boss & C. A. Mowry

"Three planets, Venus, Mercury, and Jupiter, were seen, as were the stars, ϵ Pegasi, ϵ Cygni, and α Aquilae. Some bystanders reported seeing Vega overhead and Arcturus in the west."

24 JAN 1925 1925 I
Pop. Astr. 33, 526 (1925)
Martha's Vineyard, Mass.
Eleanor A. Lamson

"The planets Venus, Mercury, and Jupiter were seen during totality, as was also the star α Aquilae."

24 JAN 1925 1925 L
Pop. Astr. 33, 532 (1925)
Halfway between Wallingford and New Haven, Conn.
Expedition from the Amherst College Observatory

"Practically all observers noted the three planets to the west of the sun and several commented upon the appearance of Saturn in the southwest. The number of stars seen varied with different observers from three to seven."

19 JUN 1936 1936 A
Observ. 59, 259 (1936)
Aboard s.s. "Strathaird' $37^{\circ}08'$ N. $23^{\circ}30'$ E.

"Venus within two degrees of the Sun was very brilliant. Mars was easily seen with binoculars, and Dr. Comrie saw it with the naked eye. So far as can be ascertained no one saw any other object."

8 JUN 1937 1937 B
Publ. Astr. Soc. Pac. 49, 188 (1937)
Pacific Ocean
J. Q. Stewart & J. Stokley

"Only the brightest planets and stars appeared - Venus, Mercury, Sirius, Betelgeuse, Procyon, and Possibly Capella."

8 JUN 1937 — 1937 C
Pop. Astr. 45, 356 (1937)
Moro, Peru
Mr. Bailey

"Mr. Bailey from Moro reported that he saw Mars, the Southern Cross, Canopus, Sirius, and stars down to the third magnitude."

1 OCT 1940 — 1940 A
Occ. Notes Roy. Astr. Soc. #9, 119 (1941)
Calvinia, Cape Providence, S. Africa
J. Jackson

"During totality a number of stars were seen. The more conspicuous besides the planet Mercury were Spica, Arcturus, Antares and the Pointers to the Southern Cross. Mrs. Jackson saw all four stars of the Southern Cross when she looked for them near midtotality.

Part 3

Other Comments on the Darkness

Year 1560 1560 A

Bureau des Long. Annuaire p. 625 (1842)

"Les historiens de l'eclipse de 1560, an disant qu'après la disparition du Soleil on ne voyait pas assez pour poser le pied; que les ténèbres étaient plus profondes que celles de la nuit."

The historians of the eclipse of 1560 said that after the disappearance of the sun that one was not able to see to position the foot; that the darknesses were more profound than those of the night.

12 MAY 1706 1706 A

Phil. Trans. 25, 2244 (1706)
Geneva, Switzerland
J. Chr. Facio Duiller

"And during three minutes it was impossible to read."

22 APR 1715 1715 A

Phil. Trans. 20, 216 (1715)
Upsala, Sweden

"As to the darkness, it was such that they could scarce distinguish one another."

22 APR 1715 1715 B

Phil Trans. 20, 250 (1715)
London, England
Dr. Edmund Halley

"As to the degree of darkness, it was such that one might have expected to have seen many more stars that I find were seen at London."

16 JUN 1806 1806 A

Trans. Amer. Phil. Soc. 6 (old series), 266 (1809)
Kinderhook, N. Y.
Mr. J.J. de Ferrer

"The darkness was not so great as was expected, and without doubt was greater than that of the full moon."

17 SEPT 1811 1811 A

Mem. Amer. Acad. Arts Sciences 3, 251 (1811)
Burlington, Vermont
Prof. James Dean

"On the whole, the diminution of light was much greater than I expected. Making a random conjecture, I should represent it as dark as when the sun had descended 6^{o} or 8^{o} below the horizon."

8 JUL 1842 1842 A
France: Bureau des Long. Annuaire p. 283 (1846)
Venice
Voyagers on a steamer

"Sur les lagunes de Venise, les voyageurs du bateau à vapeur noterent, pendant l'eclipse totale, que la colonne de fumée sortant de la cheminée n'était plus visible. Les parcelles de charbon enflammées que la colonne entraine toujours avec elle, semblaient ainsi isolées et produisaient un très-bel effet."

On the lagoons of Venice voyagers on a steamer noticed, during the total eclipse, that the column of smoke coming out of the chimney was not visible. Particles of enflamed carbon (sparks) that the column carried were always with them, seeming thus isolated and produced a very beautiful effect.

8 JULY 1842 1842 G
Arago, Bureau des Longitudes, Annuaire for 1842, p. 282-3 (1843)

"A Lodi, M. Piloa lisait des caractères de moyenne grandeur quand le livre se trouvait incliné de manière à être éclairé par la lumière rougeâtre provenant de l'horizon. Là où l'horizon était caché par des édifices, l'obscurité devait évidemment paraître beaucoup plus grande."

At Lodi, M. Piola read characters of medium size when the book was tilted in such a manner as to be illuminated by the reddish light coming from the horizon. Where the horizon was hidden by buildings the darkness appeared evidently much greater.

21 DEC 1843 1843 A
Mem. Roy. Astr. Soc. 15, 173 (1840)
Parratt Lat $11^{o}45'$ N. Long. $5^{h}3^{m}$ E.
John Caldecott

"Never quite dark or too dark to read off the actinometer."
Clear sky.

28 JUL 1851 1851 A
Memoirs of the Roy. Astr. Soc. 41, 187 (1879)
Bue Island, Norway
Prof. C. Piazzi Smyth

"The present darkness, however, though somewhat appalling to the senses, and sufficient to make a ship in the neighborhood stop its course and furl its sails, was not after all, so very intense: as not only small print could be read, but the marks of a pencil could be seen in sketching the appearances."
Sky was so cloudy sun or moon couldn't be seen during totality.

28 JUL 1851 1851 B
Memoirs of the Roy. Astr. Soc. 41, 187 (1879)
Frederiksvaern
Prof. J.C. Adams

"The light remaining was only just sufficient to enable me to read off the face of a box chronometer which I had with me."

28 JUL 1851 1851 C
Memoirs of the Roy. Astr. Soc. 41, 187 (1879)
Christiania
Mr. Robert Snow

"When total darkness took place it was not easy to decipher the figures of a watch held in the hand."

28 JUL 1851 1851 D
Memoirs of the Roy. Astr. Soc. 41, 187 (1879)
Gottenburg
The Rev. Temple Chevallier

"The general light of the sky [during totality] was sufficient to render the shadow cast by the taper imperceptible when the taper was 193 inches from the screen."

28 JUL 1851 1851 E
Memoirs of the Roy. Astr. Soc. 41, 188 (1879)
Trollhattan
Mr. Lassell

"The amount of darkness may be appreciated from the fact that on withdrawing my eye from the telescope, I could neither see the seconds hand of my watch, nor the paper sufficiently to write the time down."

28 JUL 1851 1851 F
Memoirs of the Roy. Astr. Soc. 41, 188 (1879)
Christianstadt
Mr. Miland

"During the totality, I experienced some difficulty in reading the seconds of the chronometer I held in my hand, and was glad of the assistance afforded me by the lighted candle at my feet."

28 JUL 1851 1851 G
Memoirs of the Roy Astr. Soc. 41, 188 (1879)
Hill near Gottenburg
Sir G.B. Airy

"A candle had been lighted in a lantern about a quarter of an hour before the

totality. Mr. Hasselgren was unable to read the minutes of the chronometer face without having the lantern held close to the chronometer. I had prepared for the occasion a circle described upon a card: I desired much to make a drawing of the prominences, at least of their positions on the limb of the moon, by marking them on this circle, but it was impossible for me to see it, and I was obliged to approach very closely to the lantern, in order to make the smallest memorandum on the card."

15 MAR 1858 — 1858 A
Roy. Soc. of London Proc. 9, 214-215 (1858)
Scotland - England
Collected by Edward Joseph Lowe

"The darkness, although felt, was by no means so great as had been expected; yet this was in a great measure owing to the overcast sky."

"Practically it was dark, the impossibility of reading the instruments at Isham, Towcester, and Grantham, was a certain measure. I have seen greater apparent darkness produced by a storm, and yet the darkness was not such as to prevent instruments being read."

Overcast.

18 JUL 1860 — 1860 A
Amer. Jour. of Sci. 81, 141 (1861)
N.W. British America 53°46' N. Lat.
Wm. Ferrel

"The darkness was at no time so great that the title page of the Nautical Almanac could be read with facility."

Clouds completely obscured the eclipse.

18 JUL 1860 — 1860 B
Amer. Jour. of Sci. 80, 283-284 (1860)
Cape Chudleigh, Labrador
F.A.P. Barnard

"The darkness which prevailed during total obscuration was not as remarkable as had been anticipated by most of the observers. The present writer, for instance, found no difficulty in making pencil notes at this time, or in reading lines written in pencil in other parts of his note book. It was not necessary to bring the book nearer to the eye than usual."

Clouds continually drifted over the sky concealing the eclipse at times.

18 JUL 1860 1860 C
Amer. Jour. of Sci. 80, 287 (1860)
Steilacoom, Washington Territory
Lt. J.M. Gillis U.S.N.

"It was then so dark that I found it impossible to recognize the second's dial of the chronometer (the gold one) and Mr. James Gillis was called to bring his lantern and read the time at which I should indicate the second internal contact of the limbs."

18 JUL 1860 1860 D
Amer. Jour. of Sci. 80, 288 (1860)
Mount Saint-Michel, Palmas, Spain
A. Secchi

"The light was strong enough to enable one to distinguish small objects, and to read without difficulty ordinary books."
A thunder cloud a short distance from sun, otherwise clear.

18 JUL 1860 1860 E
Roy. Soc. of Lond. Proc. 12, 61-62 (1862)
Rivabellosa, Spain
Warren de La Rue

"The darkness during the totality was not nearly so great as might have been expected from accounts of previous eclipses. The illumination was markedly distinct from that which occurs in nature on any other occasion, and certainly was greater than on the brightest moonlit night, although at the time the light appeared to the author as less bright than what he remembered of bright moonlight. By subsequent trials he was led to conclude that the light during a total eclipse most resembles that degree of illumination which exists in a clear sky soon after sunset, when, after having made out a first magnitude star, other stars of less brilliancy can be discerned one after another by an attentive gazer."

18 JUL 1860 1860 F
Memoirs of the Roy. Astr. Soc. 41, 188 (1879)
Burgos
Mr. T.C. Janson

"The darkness in the rooms was so great that we were afraid of running against the furniture in changing our places from the telescope to the balcony."

18 JUL 1860 1860 G
Memoirs of the Roy. Astr. Soc. 41, 190 (1879)
Vitoria, Spain
Frau Madler

"I could not only easily distinguish objects during totality, but could read the finest writing and even the scale of the thermometer."

18 JUL 1860 1860 H
Memoirs of the Roy Astr. Soc. 41, 189 (1879)
St. Lorenzo Mountain alt 6150'
Mr. G.H. James

"The darkness was not so great as I had anticipated. I was able to see the divisions of the thermometers, but could not read them, being unable to observe the mercury."

18 JUL 1860 1860 I
Memoirs of the Roy. Astr. Soc. 41, 189 (1879)
Pobes
M. Otto Struve

"I noticed also a striking difference between the eclipses I had formerly observed (1842 at Lipezk and 1851 at Lomza) and the present, with regard to the degree of darkness on the earth. Though I allowed myself only for a few seconds about the middle of totality, to turn my eye from the telescope to the surrounding country, this short inspection was sufficient to leave with me the full impression that this time the degree of darkness was considerably less than on the former occasions, and particularly than in 1842."

"M. Otto Struve adds that in 1842 he estimated the light during totality to be nearly equal to that of twilight at 12 o'clock on a clear night about the time of the summer solstice in the latitude of St. Petersburg. In 1860 he estimated the darkness to be equal to that of twilight at 11 o'clock at night at the same period of the year - a light by which one is able to read and write without any particular exertion of the eyes."

18 JUL 1860 1860 J
Memoirs of the Roy Astr. Soc. 41, 189-190 (1879)
Hill above Herena
Sir G.B. Airy

"About the middle of totality I ceased for a while, in order to view the prospect with the naked eye. The general light appeared to me much greater than in the eclipses of 1842 and 1851 (one cloudy, the other hazy), perhaps ten times as great; I believe that I could have read a chronometer face at a distance of twelve inches.

...rtheless it was not easy to walk where the ground was in the least uneven, and much attention to the footing was necessary."

18 AUG 1868 1868 A
Roy. Soc. of London Proc. 17, 75-79 (1868)
Beejapoor
Capt. C. T. Haig

"We therefore felt at leisure to make our remarks on the degree of darkness, which we were surprised to find so far from total. We could easily write, read our writing, and read the seconds of our watches without the aid of artificial light."

"It is very curious how the darkness during totality seems to have differed in degree in different places. At Beejapoor we were told that down below in the town the darkness was so great that it was not possible to see ones own hand. We thought the account might be an exaggeration; but we afterwards learnt that at Moolwar a gentleman dropped part of an eyepiece of a telescope, and that it was not possible to find it even by placing the eye close to the ground, until after the end of totality." Openings in the nimbi gave glimpses of the sun through the cirrocumuli.

18 AUG 1868 1868 B
Phil. Trans. 169, 147 (1878)
Siam
Sir Harry St. George Ord

"The darkness was so considerable that at a distance of a few feet a person's features were undiscernible and all sense of distance appeared to be lost, the thermometers could not be read without a light held close to them."

18 AUG 1868 1868 C
Roy. Soc. of Lond. Proc. 17, 83-86 (1868)
Ba...ram Pt., Bornei
J. Pope Hennessy

"The moment of maximum darkness seemed to be immediately before the total obscuration; for a few seconds nothing could be seen except objects quite close to the observers."

"Though the darkness was by no means so great as I had expected, I was unable to mark the protuberances in my note-book without the aid of a lantern, which the sailors lit when the eclipse became total."
Clear - no clouds near the sun.

18 AUG 1868 1868 D
Memoirs of the Roy. Astr. Soc. 41, 190 (1879)
Vumpurthy
C. Ragoonatha Chary

"I can safely say that it was quite as dark as on a clear starlight night. I had to use lamp-light when looking for the time by the chronometer, and it was impossible to recognize the face of a person standing within a distance of three yards. Lighted candles appeared just as bright as in the night-time, and I was told that my lights were distinctly seen three-quarters of a mile off."

18 AUG 1868 1868 E
Memoirs of the Roy. Astr. Soc. 41, 191 (1879)
Wha-Tonne
M. Tisserand

"L'obscurité fut assez intense durant la totalité; en plein air, on distinguait aisement des caractères d'écriture, mais, à l'intérieur de la cabane de l'equatorial, M. Tisserand fut obligé de prendre une lampe pour lire le tambour de son micromètre."

The obscurity was fairly intense during totality; in the open air, one could distinguish easily the characters of writing, but, in the interior of the equatorial hut, M. Tisserand was obliged to use a lamp to read the drum of his micrometer.

7 AUG 1869 1869 B
Jour. Franklin Inst. 150, 145 (1900)
Ottumwa, Iowa
C.F. Himes

"On inquiry Mr. Zentmayer replied that it was too dark to make the adjustment of the exposure slide required by the feeble actinic corona. The lantern, very thoughtfully provided for such a contingency hung above his head, but unlighted."

7 AUG 1869 1869 CA
Memoirs of the Roy. Astr. Soc. 41, 191 (1879)
Des Moines, Iowa
Mr. Eastman

"I conclude that the light during the totality on Aug. 7th was about equal to that on a clear moonless evening, at the time when third-magnitude stars can be easily seen."

7 AUG 1869 1869 F
J. Roy. Astr. Soc. Canada 19, 25 (1925)
Payson, Illinois
J.A. McKellar

"The darkness seemed to last longer than it did on 24 January 1925. Stars appeared more numerous in the sky near the eclipsed sun. I did not notice if any were visible farther away. Another feature -- the darkness was more pronounced in the 1869 eclipse than at the recent one."

7 AUG 1869 1869 H
Pub. of the the U.S. Naval Obs. Appendix II, 180-181 (1869)
W.S. Gilman Jr.

"During totality the seconds on our watch faces could not be read without the assistance of the lamps placed in the windows of the house to aid us at the juncture. The time could with difficulty be told by the larger hands."

"The gloom of totality did not impress me as being at all like that of moonlight, but rather like the sombre light of an approaching thunderstorm."

7 AUG 1869 1869 K
Pub. of the U.S. Naval Obs. Appendix II, 201 (1869)
Plover Bay, Siberia
J.A. Rogers

"The darkness was not so intense as I had anticipated; but there was apparently much less light than the twilight of the preceding midnight. I had taken the precaution to illuminate the face of my chronometer by artificial light, and thought it would not have been possible to distinguish the numerals on the dial without it."

22 DEC 1870 1870 A
Nature 3, 195 (1871)
San Antonio Lat 36°37' N. Long 24'W.
Rev. S.J. Perry

"The darkness was never sufficient to prevent sketching with comfort without the aid of a lamp."
Thin cirrus enveloped the sun & obscured most of the southern sky.

22 DEC 1870 1870 BA
Memoirs of the Roy. Astr. Soc. 41, 191 (1879)
Syracuse, Sicily
Mr. Brothers & Mr. Fryer

"The darkness was such that whilst a large dialled chronometer could be read in the open air the wife of the consul could not find some pieces of glass that were lying on the table of the dining-room of their house."

22 DEC 1870 1870 BB
Washington Observations for 1869 Appendix I, 29 (1871)
Syracuse, Sicily
Prof. Hall

"The darkness during total eclipse was much less than during the eclipse of August, 1869."

22 DEC 1870 1870 CA
Nature 3, 196 (1871)
Gibraltar
R.M. Parsons

"The darkness was considerable, but not so great as when I observed the Total Eclipse of 1860, at Nisqually, in an unclouded sky. Then a lamp was necessary to enable a white-faced pocket chronometer to be read; yesterday I could see the divisions distinctly at the distance of eight inches without such aid."
Dense cloud covered the sun.

22 DEC 1870 1870 D
Observ. 2, 190 (1878)
Jerez
F.C. Penrose

"The darkness was such that I had difficulty in reading a few words of very distinctly printed matter, of a type nearly as large as that employed in the foot-notes of the 'Observatory',"
Partially Clouded.

22 DEC 1870 1870 E
Nature 3, 196-197 (1871)
Seville
M.E.A. De Cosson

"The charcoal burners' fires in the mountains, some five miles distant were plainly visible."

22 DEC 1870 1870 F
Nature 3, 197 (1871)
Oran

"At no time however, during the totality, was it difficult to see the seconds on the face of a watch. The light was that of a cloudy evening, about an hour after sunset."

22 DEC 1870 1870 G
Washington Observations for 1869 Appendix I, 60 (1871)
Prof. Harkness

"The general illumination of the atmosphere was considerable; in fact, it was not really dark, for, in addition to the outlines of objects, the details were also visible to a considerable extent."

12 DEC 1871 1871 A
Nature 5, 353 (1872)
Number VI Island, Australia

"There was no total darkness, owing, probably, to the amount of light diffused in the clouds. During totality, newspaper print could be read without much difficulty."
Completely clouded.

6 APR 1875 1875 A
Phil. Trans. 169, 147 (1878)
Bangkok, Siam
J.N. Lockyer & A. Schuster

"Though the lamps had been lighted for those who had to draw, write, or read, the lamps were blown out by the wind, but no inconvenience whatever was produced by this.

The signal for the beginning and end of totality could be seen without difficulty at the small observatory 40 yards off, and Mr. Lott could read a small watch hung up a distance of 1 1/2 feet from his face inside a shed which did not admit any direct light from the corona."

"It was quite as intense as a bright full moon."
Cloudless but hazy.

29 JUL 1878 1878 A
Amer. Jour. of Sci. 117, 122-123 (1879)
Rawlins, Wyoming Territory
George F. Barker

"Preparations had been made for using artificial light for reading the circles, but this was found not to be at all necessary. The amount of light seemed to be nearly or quite equal to that given by the moon when ten days old."

29 JUL 1878 1878 B
Observ. 2, 190 (1878)
Denver, Colorado
F.C. Penrose

"The diffused light was so great that I had no difficulty during totality in

seeing very fine pencil-lines on the paper I was using for my memoranda. I had a lamp at hand, but made no use of it."
Matter near the sun.

11 JAN 1880 1880 A
Observ. 3, 391 (1880)
Santa-Lucia
George Davidson

"Mr. Davidson did not even look for Vulcan, as the sky was too bright on account of the contracted diameter of the cone of shade."

17 MAY 1882 1882 A
Proc. Roy. Soc. (Edinburgh) 11, 830 (1882)
Sohag, Egypt
J. Y. Buchanan

"The darkness was not so great that I could read a rather closely graduated thermometer without difficulty."
Clear except for desert dust in the air.

6 MAY 1883 1883 A
Nature 28, 145 (1883)
Caroline Island

"The light during the middle of totality was equal in intensity to that of the full moon."

6 MAY 1883 1883 B
Phil. Trans. 180A, 134 (1889)
Caroline Island
C. R. Woods

"The amount of illumination of the sky seemed little less than the Egyptian eclipse."
Very cloudy.

9 SEPT. 1885 1885 A
Monthly Notices Roy. Astr. Soc. 46, 24 (1885)
Wellington, New Zealand
C. R. Marten

"The darkness was not so great as I had anticipated, being equal to that of a moonlight night in the Moon's first quarter. A watch face could be easily read at the darkest period."
Cloud around the horizon.

9 SEPT 1885 — 1885 B
Trans. Roy. Soc. New Zealand 18, 379 (1885)
Nelson, New Zealand
Rev. Dr. Suter

"The darkness was not exactly that of night. As to the degree of light, it seemed to be paralleled by the amount of light diffused about when the moon is nearly half full."

29 AUG 1886 — 1886 AA
Phil. Trans. 180A, 345 (1889)
Carriacou Island
E.W. Maunder

"The light during totality was feeble, but was just barely bright enough to enable me to read the programme which I had written out in a bold round hand, and had posted on top of the coronal camera."
Cloudy but sun was seen.

29 AUG 1886 — 1886 AB
Phil. Trans. 180A, 358 (1889)
Carriacou Island
Rev. S.J. Perry

"The darkness was never much less than that of a fair moonlight night, but during totality the light was not equal to that of a full moon in a clear sky."
Cloudy and raining but sun was seen.

29 AUG 1886 — 1886 BA
Nature 34, 499 (1886)
Grenada
A "Times" correspondent

"This was certainly the darkest eclipse since eclipse records have been in vogue."
Cloudy but sun was seen.

29 AUG 1886 — 1886 BB
Observ. 9, 403 (1886)
Grenada
Prof. Tacchini

"The darkness during the total phase was much greater than during the eclipse watched from Caroline Island."

19 AUG 1887 1887 A
Sid. Mess. 7, 1 (1888)
Steglitz, Germany

"The totality itself was not seen, but during its continuance the darkness was so intense that a chronometer could only be read with difficulty."

19 AUG 1887 1887 B
Sid. Mess. 7, 2 (1888)
Goldap, East Prussia
Prof. Th. Albrecht

"Clouds rendered the eclipse invisible, but he determined the amount of light during totality in the following simple way: During totality he noted the greatest distance at which he could read a certain manuscript written with a lead pencil, and in the evening he watched for the time when the same manuscript was again just legible at the same distance, and found it to be forty minutes after sunset. Fortunately the condition of the sky with respect to cloudiness was the same in the evening as during the eclipse."

19 AUG 1887 1887 C
Sid. Mess. 7, 2 (1888)
Kleistshohe, Germany
Dr. Lachman, Mr. Pechule & Prof. Tietjen

"The darkness became so intense that lanterns were required in order to see to read."
Sun was hidden by clouds.

19 AUG 1887 1887 D
Sid. Mess. 7, 2 (1888)
Kolmar, Germany
Dr. Kober & Prof. Reimann

"The gloom was so deep that it was impossible to read the face of a watch without artificial light."
The sky was covered by clouds.

19 AUG 1887 1887 E
Sid. Mess. 7, 8 (1888)
Nolinsk, Russia

"The greatest darkness occurred about 7:45 A. M., and was like that of a moonless night."
Rained.

19 AUG 1887 1887 F
Sid. Mess. 7, 8 (1888)
Tomsk, Russia

"Stars were visible, and the darkness was so great that in most houses it was necessary to light candles or lamps."
Clear sky.

19 AUG 1887 1887 G
Sid. Mess. 7, 163 (1888)
Mount Blaghodat, Russia
Dr. B. Von Englehardt

"During totality it was so dark that neither notes nor chronometer could be read without a lantern."
Few clouds.

19 AUG 1887 1887 H
Amer. Met. J. 4, p. 363 (1887)
Chlamostino, Russia
W. Upton & A. L. Rotch

"The darkness rapidly increased until it was about equal to that one-half hour after sunset. The second-hand of a watch could easily be placed throughout totality."
Cloudy.

1 JAN 1889 1889 A1
Sid. Mess. 8, 171 (1889)
Liegan, California
T. Coffin

"No candle was necessary for the reading of my watch or to make the drawing during totality."
Cloudy.

1 JAN 1889 1889 B1
Sid. Mess. 8, 176 (1889)
Sierra Nevadas
C.W. Irish

"I found by comparison on the day of the eclipse, that the darkness was just about equivalent to the 40 minutes after sundown experiment."
Cloudy.

1 JAN 1889 1889 C1A
Sid. Mess. 8, 185 (1889)
Chico, California
Carleton College Eclipse Party

"We had no means of determining the light of totality, and can only say that it was necessary to use artificial light to carry on our sketching."
Cloudy but sun was seen.

1 JAN 1889 1889 C1B
The Observatory 12, 107 (1889)
Chico, California

"... it was so dark during totality at Chico that lights had to be used in taking notes, which was not the case in the eclipses of 1886 and 1887."

22 DEC 1889 1889 A2
Observ. 13, 154 (1890)
Cape Ledo, Africa
Mr. Taylor

"At no time was the darkness very intense. The light from the clouds near the horizon enables the chronometer minute and hour hands to be seen at 8 feet distance and the second hand at 3 feet. The white tents of the American camp, half a mile distant, were distinctly visible."
Few breaks in clouds.

16 APR 1893 1893 A
Observ. 18, 370 (1895)
Mina Bronces, Chile
J. M. Schaeberle

"The darkness during totality was not very striking: 'the second hand of a watch was easily seen'; 'lawn tennis could have been carried on in the light'."
Sky was absolutely free from clouds, smoke, or haze.

16 APR 1893 1893 B
Phil. Trans. 187 A, 441 (1896)
Fundium, Senegal, West Africa
W. de W. Abney & T.E. Thorpe

"The actual gloom during this phase of the eclipse at Fundium was certainly much less than at Grenada in 1886."
Haze caused by finely-divided solid matter. Practically free from cloud.

22 JAN 1898 — 1898 A

Observ. 21, 118 (1898)
Viziadrug, India
From the "Times of India"

"The darkness owing to the great clearness of the atmosphere was not intense. Newspaper print could be easily read or the position of the second hand of a watch noted without the assistance of a lantern."

28 MAY 1900 — 1900 A

Observ. 23, 247 (1900)
Ovar

"At Ovar the scene during totality was considered as bright as it was in India at the eclipse of 1898 when it was said that a newspaper could be read without artificial light."
Somewhat hazy and partially covered with light cirrus cloud.

28 MAY 1900 — 1900 B

Observ. 23, 281 (1900)
Elche, Spain
Prof. M. Moye

"Obscuration of the scene was not intense; all objects were distinctly seen; the divisions of a watch, or a newspaper, could be read without artificial light. The general illumination was very superior to that of a full moon."
Clear sky.

28 MAY 1900 — 1900 CC

Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D162 (1905)
Juliette, Georgia
Mrs. C.W. Crockett

"The light at the time was such as to enable me to see the pencil lines on my drawing board, and the impression was that of a clear late twilight.

28 MAY 1900 — 1900 D

Astrophys. J. 12, 101 (1900)
Norfolk, Virginia
Georgetown College Party

"The sky remained brighter than a full Moon night. This was found from reading different types at given distances."

28 MAY 1900 1900 EA
Jour. Franklin Inst. 150, 139-140 (1900)
Virginia Beach, Virginia
A.E. Kennelly

"The general illumination at this time was very feeble, but it was possible to read ordinary print without difficulty."
Few light cirrus clouds near horizon.

28 MAY 1900 1900 EB
Jour. Franklin Inst. 150, 146 (1900)
Virginia Beach, Virginia
C.F. Himes

"The sudden darkness of totality did not seem as intense, and, as a consequence, the stars did not seem to spring out with the same brightness." [as in the eclipse of 1869]

28 MAY 1900 1900 EC
Jour. Franklin Inst. 150, 150 (1900)
Virginia Beach, Virginia
F.H. Ives

"The light appeared very much stronger than that of the brightest moonlight, apparently quite sufficient for reading fine print."

28 MAY 1900 1900 F
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D78 (1905)
Reservoir Hill
Prof. J.N. Hart

"The eclipse was much lighter than I had expected, all near objects being distinctly visible during totality."

28 MAY 1900 1900 G
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D82 (1905)
Barnesville, Georgia
Prof. O. Ashmore

"The light during totality is difficult to estimate. I had no difficulty in making notes or in reading the chronometer. I think that ordinary newspaper print could have been read, but that was about the limit."

28 MAY 1900 1900 H
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D167 (1905)
Washington, Georgia

"Plenty of light to read the chronometer, about equal to twilight about ten minutes after sunset, except that it was all around the sky uniformly. The sky

illumination was fine, like stage illumination with hidden lights. It could certainly not be called night."

18 MAY 1901 — 1901 A
Observ. 24, 375 (1901)
Mauritius
E.W. Maunder

"If my recollection serves me aright, the darkest of these eclipses was that of 1886. I cannot decide between 1898 and the present one, but the general illumination in 1900 was certainly greater than in the other three."
Partially cloudy.

17 MAY 1901 — 1901 BB
Pub. of the U.S. Naval Obs. Vol IV, Appendix I, D210 (1905)
Solok, Sumatra
Mr. Curtis

"In view of the probable darkness on account of the long totality, lanterns were provided for each instrument, but they were found to be entirely unnecessary except in the dark room of the 60-foot camera. The light was sufficient to enable anyone to read the face of a chronometer or an ordinary printed page without difficulty. Mr. Curtis remarks that the eclipse of May 1900, which he observed under very favorable conditions at Thomaston, Ga., was certainly much darker, and that it was as light at Solok at midtotality as it was in Georgia ten to twenty seconds before second contact. The light was about the same as that of a day with a sky overcast with moderately thick clouds."

30 AUG 1905 — 1905 A
Nature 75, 163-164 (1906)
Alcocebre

"During this last eclipse the brightness was probably ten times that of a full moon."

30 AUG 1905 — 1905 C
Observ. 28, 381 (1905)
Alcala de Chisvert, Spain
Prof. M. Moye

"At totality light was surprisingly intense. I did not find any difficulty in sketching my drawing or in reading small letterpress. The features of the landscape, the details of a railway-engine, the divisions of a watch --- all were seen very easily. The eclipse of 1900 is recorded as a bright one; for myself I believe that of 1905 yet brighter."
Scattered clouds.

30 AUG 1905 1905 D
Publ. Astr. Soc. Pac. 18, 21 (1906)
Alhama, Spain
W. W. Campbell & C. D. Perrine

"This was a 'dark' eclipse, notwithstanding the light diffused by the clouds. It was very much darker than those of India, 1898 and Georgoe, 1900, and darker than that of 1901 in Sumatra. The amount of cloudiness at the two stations in 1901 and 1905 was not very different. At the former eclipse Mr. Perrine could read the figures in a table of logarithms easily, while at the latter he had to look closely to distinguish them."
Sun seen through thin clouds.

30 AUG 1905 1905 G
Pub. of the U.S. Naval Obs. Vol X, Part II, Appendix, B31 (1924)
Daroca, Spain
C. P. Olivier

"The first impression received was that the eclipse was an exceedingly light one. Ordinary print could be read, and my notes were written without difficulty."

30 AUG 1905 1905 I
Pub. of the U.S. Naval Obs. Vol X, Part II, Appendix, B177 (1924)
On the U.S.S. Minneapolis off Capricorn, Spain
Capt. J. M. Miller

"$1^h16^m20^s$ p.m. Totality - Darkness seemed to be that of about an hour after sunset in this latitude, compared with ordinary daylight. Impossible to distinguish color of foliage and hills on shore. White houses indistinctly visible."

3 JAN 1908 1908 AA
Observ. 31, 294 (1908)
Flint Island
Prof. W. W. Campbell

"The eclipse was a very 'light' one, not nearly so dark as those of 1898, 1900, and 1905."

3 JAN 1908 1908 AB
Nature 78, 9 (1908)
Flint Island

"The eclipse does not seem to have been a dark one. It is stated that it never became too dark to read large figures, in spite of the instruments being surrounded by trees. Another statement is that a newspaper could have been read without any difficulty whatever. Captain G. H. Lacy, who observed the eclipse

from the bridge of the 'Taviuni' compared the light during totality to that which would be produced from an arc lamp placed on deck."

9 MAY 1910 — 1910 AA
Monthly Notices Roy. Astr. Soc. 70, 649 (1910)
Tasmania
W. F. Gale

"The gloom during totality was estimated as nearly equal to the darkness of a bright moonless night."
Cloudy and rainy.

9 MAY 1910 — 1910 AB
Monthly Notices Roy. Astr. Soc. 70, 652 (1910)
Tasmania
E.C. Driffied

"The darkness during totality would be equal to a medium twilight."
Cloudy and rainy.

28 APR 1911 — 1911 A
Nature 86, 313 (1911)
Vavau

"The general description of the eclipse is that it was not a dark one, and in consequence comparatively few stars were observed during totality."

17 APR 1912 (annular) — 1912 B1
The Observatory 35, 208 (1912)
St. Germain-en-Laye, France

"Indeed, there was nothing approaching darkness at any time, though the sunlight was very weird in color."

17 APR 1912 (annular) — 1912 D1
Nature 89, 242 (1912)
Eaubonne, France
J.Y. Buchanan

"In the last moments before totality the rate of extinction of light was very great, and I compared it with that which would take place in a well-illuminated room when a shutter is rapidly drawn down over the window. In the case of the 1882 eclipse the shutter was drawn quite down, and nocturnal darkness was produced with the appearance, not only of all the principal stars, but also of an unsuspected comet in the immediate vicinity of the sun. In the case of the present eclipse the shutter was at first being drawn down quite as rapidly, but it stopped

short, and was almost immediately pulled up again. I have no doubt whatever that if the eclipse had been total, it would have been a very dark one."

17 APR 1912 (annular) 1912 E1
Nature 89, 277 (1912)

"Quite a number of observers remarked on the unexpected darkness of the eclipse."

17 APR 1912 (annular) 1912 F1
Astronomie 26, 248 (1912)
Paris, France
G. Renaudot

"A 12^h5^m ... Le jour est tellement affaibli que le lis difficilement les divisions du thermomètre.

At $12^h10^m30^s$, phase maximum ..."

At 12^h5^m ... The day is attenuated to the extent that I read with difficulty the divisions of the thermometer.

At $12^h10^m30^s$, maximum phase.

17 APR 1912 (annular) 1912 G1
Astronomie 26, 330 (1912)
In a balloon about 800-900 meters high near Rethondes, France
Crouzon, Nicolleau and Tissandier

"Brutalement, une autre sensation se produisait à $12^h11^m51^s$, c'était l'obscurité; elle dura deux secondes environ. Cependant, nous avons pu lire un thermomètre fronde et un chronomètre."

Suddenly, another sensation occurred at $12^h11^m51^s$, that of darkness; it lasted about two seconds. Nevertheless, we were able to read a sling thermometer and a chronometer.

10 OCT 1912 1912 A2
The Observatory 36, 64 (1913)
Passa Quatro, Brazil
A.S. Eddington

"... as the darkness came on, the rainfall increased if anything, and the coelostats were never uncovered. The rapid increase of the darkness a few seconds before totality was very striking, as was also the almost instantaneous brightening when it was over. Probably the state of the atmosphere caused the eclipse to be an unusually dark one."

21 AUG 1914 1914 A
Compt. Rend. 159, 767 (1914)
Stromsund, Sweden
J. Bosler & H.G. Block

"Malgré la transparence du ciel, l'obscurité ne fut pas très grande."
Despite the clearness of the sky, the darkness was not very great.

21 AUG 1914 1914 B
The Observatory 37, 383 (1914)
Minsk, Russia
H.S. Jones

"The darkness during totality was not very intense."

28 MAY 1919 1919 A
Observ. 42, 392 (1919) see also p. 370
Sobral, Brazil
Mr. Davidson & Dr. Crommelin

"With regard to the July plates, we found that exposure was possible up to 25 minutes before sunrise, when the sky was of about the same brightness as during totality."

21 SEPT 1922 1922 BA
Nature 111, 128 (1923)
Wallal, Australia
J. Hargreaves & G.S. Clark-Maxwell

"The darkness during totality is stated to have been considerable, necessitating the use of lamps for plate-changing etc."

21 SEPT 1922 1922 BB
J. Roy. Astr. Soc. Canada 17, 380-381 (1923)
Wallal, Australia
Jean L. Chant

"When two minutes of the total phase had elapsed I tried to read printing from four sizes of type which had been chosen for me. The first, I am told, was pica or 12-point old style. It was easy. The next was bourgeois, or 9-point, and this was rather hard. The third was a picket Testament printed in nonpareil antique or 6-point. This was very hard. The fourth was the license at the front of the Testament. It was set in pearl or 5-point italic, and I could not read it at all."

"In the evening after the eclipse a candle was held at different distances from the various printed pages and it was found that when it was 2 feet away the illumination was approximately equal to that from the sky at the middle of the eclipse."
Perfect weather conditions.

10 SEPT 1923 — 1923 A
Pub. of the U.S. Naval Obs. Vol X, Part II, Appendix, B413 (1924)
Airplane at 16,500 ft.
Lt. L. D. Webb

"Sufficient light to read instruments."

24 JAN 1925 — 1925 H
Pop. Astr. 33, 353-355 (1925)
New Haven, Conn.
L. J. Boss & C. A. Mowry

"It was not as dark during the total phase as had been anticipated, Mr. Mowry estimated visually at about one and a half full moons."
Perfectly clear sky.

24 JAN 1925 — 1925 J
J. Roy. Astr. Soc. Can. 19, 66-67 (1925)
Welland, Ontario
A. F. Hunter

"During this two minutes ordinary print of any kind could not be read, but the hands of a watch, with a wider interval than print could be seen."
Completely clouded.

24 JAN 1925 — 1925 K
Pop. Astr. 33, 356-358 (1925)
Middletown, Conn.
Williams College Party

"How dark was it? Each observer made a subjective estimate of the darkness and then compared it with the full moon two weeks later. All agreed that it was lighter than full moon light."

"The intensity of illumination during totality was measured with a Westinghouse Foot Candle Meter. This was placed on a table about two feet above the ground and was inclined so that the scale was facing the sun. The results of two observations made during totality were .02 and .017 foot candles, corresponding to the illumination at approximately 7 feet and 7.7 feet respectively from a standard candle."

"On the evening of February 8 at about 10:45 P.M., similar observations were made at Williamstown on the intensity of illumination from the full moon. The ground at that time was well covered by snow and the conditions under which the observations were made at Middletown were duplicated as far as possible. The readings of the Foot Candle meter in this case were practically identical with those made during totality, though, to the observer, the illumination from the moon seemed less intense."

24 JAN 1925 — 1925 L
Pop. Astr. 33, 532 (1925)
Halfway between Wallingford & New Haven, Conn.
Expedition from the Amherst College Observatory

"In intensity of illumination it was recorded as about equal to that of late twilight."

"The intensity of illumination was sufficient to permit the easy reading of type on the printed folders. This type had been read with difficulty on the bright moonlight nights two weeks prior to the eclipse. Watch faces could be read with ease during totality."

Clear except close to the horizon.

14 JAN 1926 — 1926 A
Observ. 49, 223-224 (1926)
Jubaland
Senator G. Mengarini

"There was no complete obscurity during the whole eclipse such as we had observed in the eclipses of 1905 and 1914. Instead I now saw a tenuous grey lavender colour, giving sufficient light for me to be able to read the chronometers and the numerous marks on the plate-holders, so that the red lamps we had provided for the moment of totality were not needed."

In a Monsoon storm.

29 JUN 1927 — 1927 A
Monthly Notices Roy. Astr. Soc. 87, 661 (Supplementary No.) (1927)
Giggleswick

"The darkness during totality was just sufficient to necessitate the use of a flash-light in reading the chronometer."

29 JUN 1927 — 1927 B
Gerlands Beitrage zur Geophysik 19, 297 (1928)
Yorkshire, England
Lord Rayleigh

"The general illumination during totality was very much more than what has been described on some occasions."

29 JUN 1927 — 1927 C
Monthly Not. Roy. Astr. Soc. 88, 100 (1927)
Olliver Ducket, Richmond, Yorks
W.J.S. Lockyer

"The only conclusion that can be drawn, therefore, is that the illumination during totality was very much more intense than on a bright moonlight night."

29 JUN 1927 — 1927 D
Mon. Not. Roy. Astr. Soc. 88, 100 (1927)
Ringebu, Norway
G. Armellini & G. Conti

"The illumination during totality was much greater than that of a full moon. It is stated that Signor Armellini could read type 0.5 mm. high, while 2 mm. was the minimum in full moonlight."

19 JUN 1936 — 1936 A
Observ. 59, 259 (1936)
Aboard the ss. "Strathaird" 37°08' N. 23°30' E.

"The sky at totality was not very dark; print and graduation on instruments could be read easily without the aid of torches."
Clear.

8 JUN 1937 — 1937 B
Publ. Astr. Soc. Pac. 49, 187-188 (1937)
Pacific Ocean 9°49'.5 N. 133°38' W
J.Q. Steward & J. Stokley

"The general illumination, however, was surprisingly bright during totality. Our flashlights were not needed, ordinary newspaper print could be read easily. All around the horizon a high saffron glow from sunlight outside the moon's shadow produced the unexpectedly bright general illumination."
Clear around the sun, otherwise generally cloudy.

1 OCT 1940 — 1940 A
Occasional Notes Roy. Astr. Soc. #9, (1941)
Calvinia, Cape Providence, S. Africa
J. Jackson

"It seemed to me the eclipse would be dark, but actually I had no difficulty in reading the exposure times written on the cardboard I used for making exposures."

Part 4

Partial Solar Eclipses

17 APR 1912
Physikalische Zeitschrift. Leipzig 13, 852-855 (1912)
Wolfenbuttel, Germany
J. Elster & H. Geitel

Photometric Measurements of the intensity of sunlight to determine the symmetry of the solar radiation curve during an eclipse were made at Wolfenbuttel during the eclipse of 17 April 1912.

The photometer used had an attached tube 24 cm long with a diameter of 4 cm to keep out light scattered from the sky. The photometer was mounted outdoors and directed at the sun. A Jenens blue ultraviolet glass was used as a light filter.

Table 36 gives the results of the observations which are plotted in Figure 36. A correction for "the effect of the Sun's angle of elevation on the measurements" was made by means of the Lambert formula:

$$J = J_0 a^{-\frac{1}{\sin \theta}}.$$

The corrected results are given in Table 37 where J_0 is the light intensity at the upper limit of the atmosphere. Figure 37 is a plot of the corrected results. Comparison with measurements made at Palma, Mallorca during the total eclipse of 30 Aug 1905 under cloudy skies are given in Table 38.

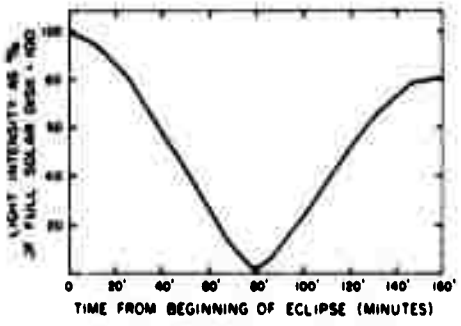

Figure 36. Light Intensity Versus Time From First Contact Recorded at Wolfenbuttel During the Solar Eclipse of 17 April 1912

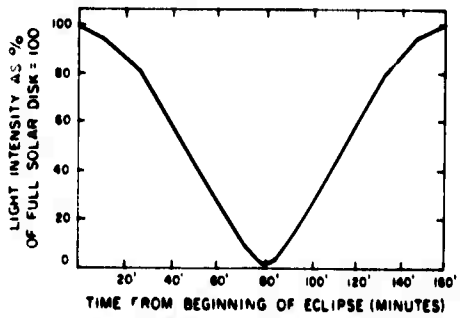

Figure 37. Light Intensity Curve Corrected for the Effect of the Sun's Angle of Elevation Recorded at Wolfenbuttel During the Solar Eclipse of 17 April 1912

Table 36. Observation Results of Partial Eclipse of 17 April 1912

Time in Minutes	Light Intensity		Elevation of Sun above horizon	Light Intensity at the Upper Limit of the Atmosphere		Remarks
				Computed From the Lambert Formula		
Computed from 1st contact at 12h 3'	Observed, in 10^{-8} amp	Computed, as % of full solar disk = 100		10^{-8} amp	In percentage of full solar disk = 100	
0	456	100,0	48° 0'	1112,6	100,0	1st contact $12^h3'$
12	429	94,1	48° 9'	1049,2	94,3	
27	365	80,0	48°18'	892,6	80,3	
42	251	55,0	47°54'	618,8	55,6	
47	220	48,3	47°42'	540,3	48,6	
57	144	31,6	47°30'	356,4	32,0	
62	106,1	23,3	47°18'	262,5	23,6	
67	70,1	15,0	47° 6'	174,4	15,7	
72	41,0	8,9	46°54'	102,3	9,2	
77	14,6	3,2	46°24'	36,7	3,4	
80	6,0	1,3	46° 4'	15,2	1,4	Maximum phase of the eclipse
83	11,2	2,5	45°43'	28,5	2,6	
87	29,1	6,4	45°25'	74,3	6,7	
102	125,0	27,4	44°30'	324,1	29,1	
117	226,8	49,7	43°24'	599,4	53,8	
132	318,8	65,3	42° 6'	863,1	77,6	
147	374,8	76,7	40°30'	1047,9	94,2	
160	385,8	79,0	39° 0'	1114,7	100,2	Last contact 2^h 42' 30'

Table 37. Corrected Results of Partial Eclipse of 17 April 1912

Descending Branch of the Light Curve		Ascending Branch of the Light Curve		Difference
Time in Min	J_o in Percent	Time in Min	J_o in Percent	
0	100	160	100	
10	95,2	150	95,9	+0,7
20	87,1	140	86,8	-0.3
30	75,5	130	74,1	-1,4
40	59,2	120	58,0	-1,2
50	43,6	110	42,0	-1,6
60	26,9	100	26,0	-0,9
70	11,0	90	11,1	+0,1
75	4,8	85	4,9	+0,1
80	1,4	80	1,4	

Table 38. Comparison of 17 April 1972 and 30 April 1905 Eclipses

Time From beginning of eclipse	0	10'	20'	30'	40'
Wolfenbuttel (Intensity as % of full solar disk)	100	95.2	87.1	75.5	59.2
Palma ( )	100	95.8	89.1	75.9	60.2
Time From beginning of eclipse	50'	60'	70'	75'	80'
Wolfenbuttel ( )	43.6	26.9	11.0	4.8	1.4
Palma ( )	43.6	26.9	11.0	3.8	1.1

30 JUN 1954

Royal Meteorological Institute of Belgium Publication Series B, No. 13
Uccle, Belgium
R. Dogniaux

Measurements of "energizing lighting of the sun and the sky at the ground on a horizontal surface, energizing diffuse lighting on a horizontal surface, and natural luminous lighting on a horizontal surface" were made during an eclipse

whose greatest phase reached a magnitude of .774 (the sun's diameter being equal to 1) at Uccle on 30 June 1954.

Results of the measurements are given in Figures 38-42. Scattered clouds were observed the day of the eclipse. Figure 38 gives the total radiation received at the ground on a horizontal surface on the day of the eclipse, the day before, and the day after. Figure 39 gives the diffuse radiation received at the ground on a horizontal surface for the same days. Figure 40 gives the "curve of the total radiation deduced from the real recording after computation of the averages over 10 minutes." The thus reduced curve shows maximums when there were breaks in the clouds, and minimums when the sun was covered by clouds. Figure 41 gives the luminous lighting of the total solar radiation on a horizontal surface measured by means of photoelectric cells. Figure 42 gives the curve of the luminous lighting of the total solar radiation deduced from the real recording after computation of the averages over 10 minutes.

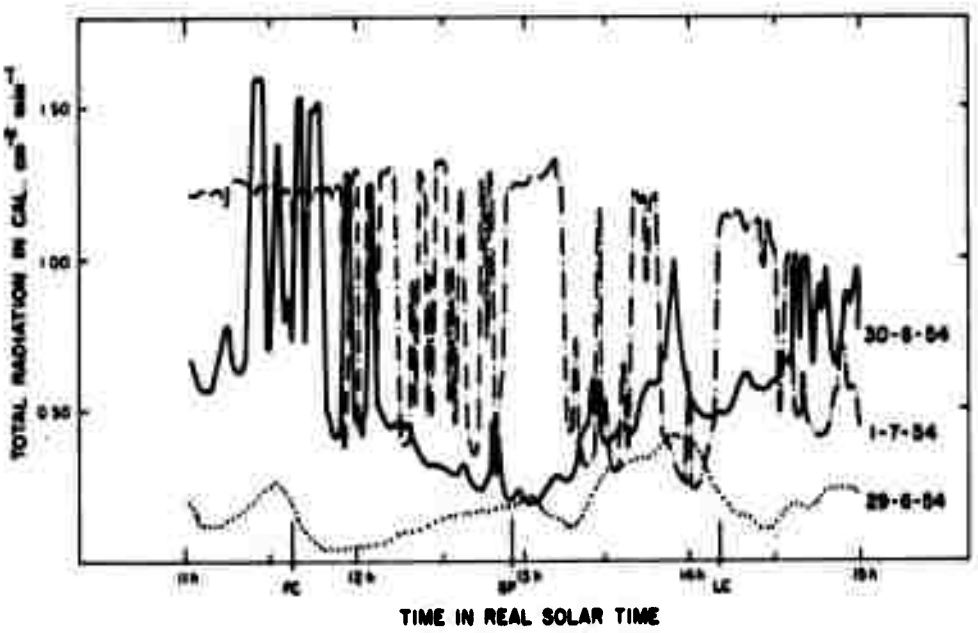

Figure 38. Energizing Lighting of the Total Solar Radiation on a Horizontal Surface Recorded at Uccle During the Solar Eclipse of 30 June 1954

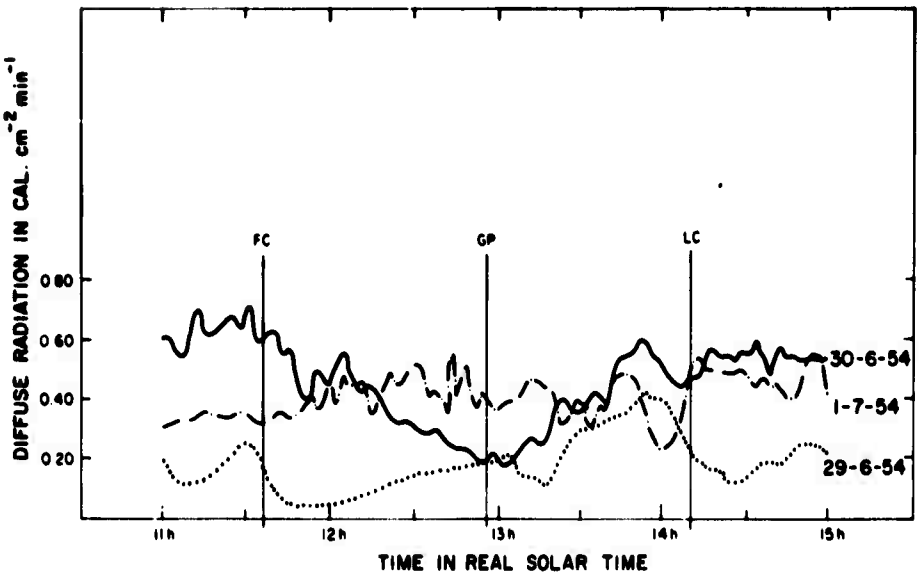

Figure 39. Energizing Lighting of the Diffused Solar Radiation on a Horizontal Surface Recorded at Uccle During the Solar Eclipse of 30 June 1954

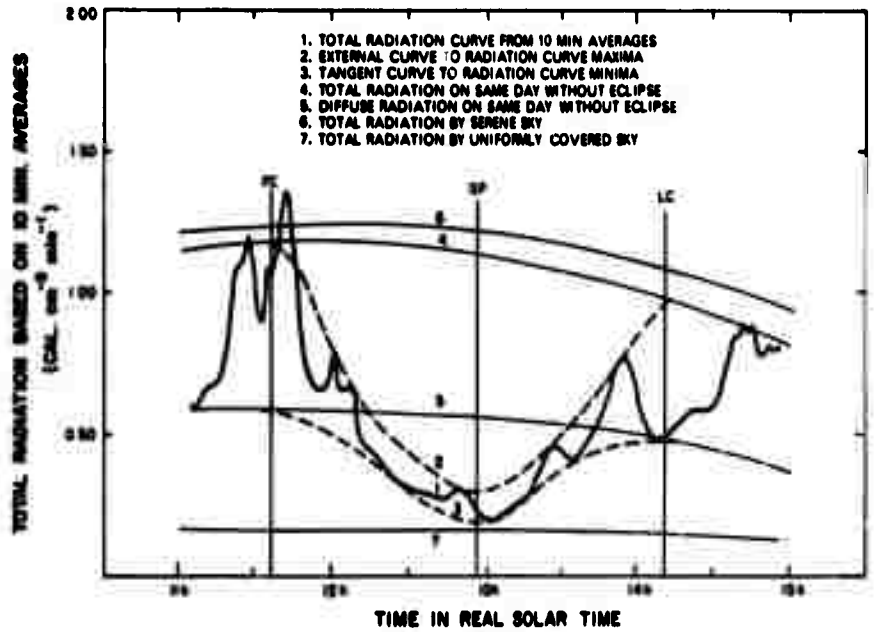

Figure 40. Energizing Lighting of the Solar Radiation on a Horizontal Surface Variation Recorded at Uccle During the Solar Eclipse of 30 June 1954

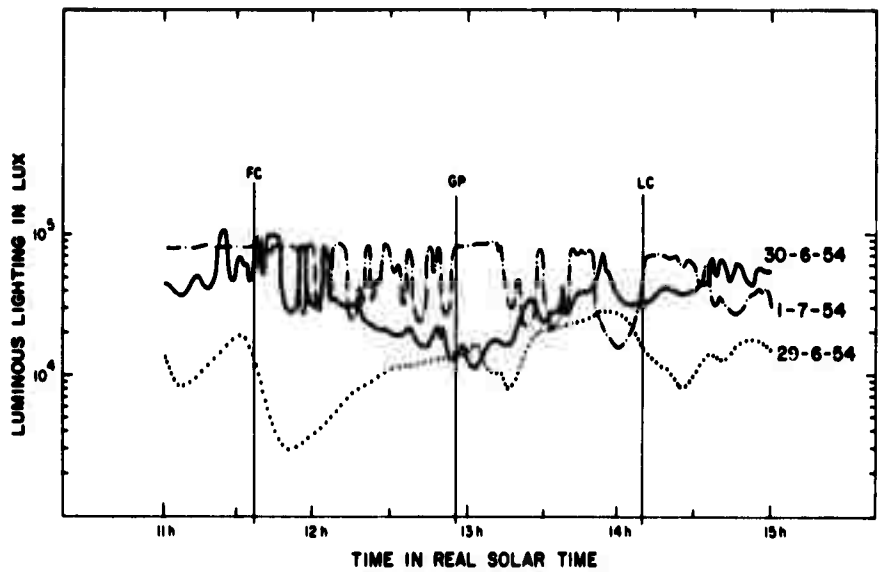

Figure 41. Luminous Lighting of the Total Solar Radiation on a Horizontal Surface Recorded at Uccle During the Solar Eclipse of 30 June 1954

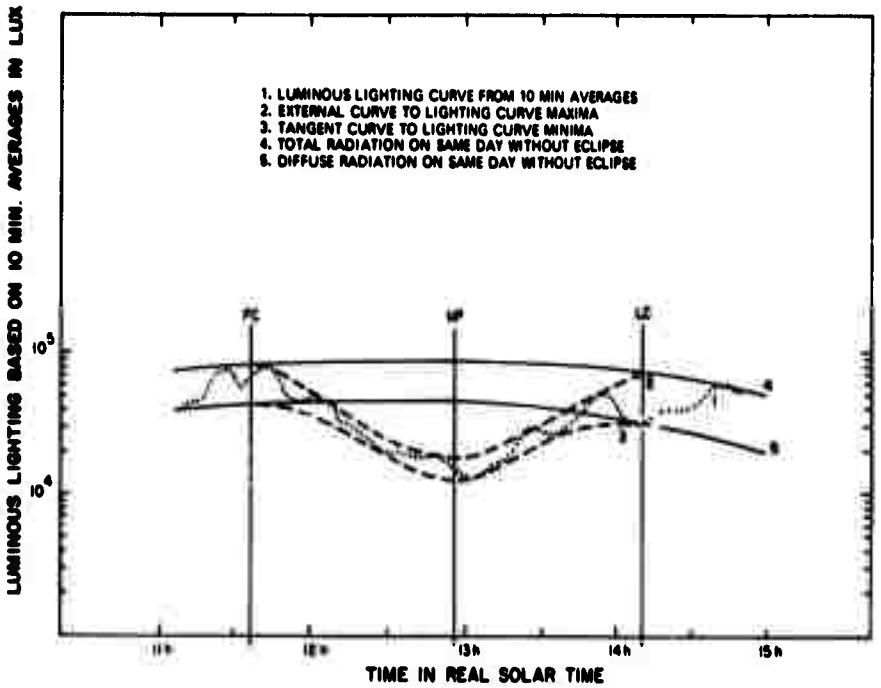

Figure 42. Luminous Lighting of the Total Solar Radiation on a Horizontal Surface Variation Recorded at Uccle During the Solar Eclipse of 30 June 1954

14 DEC 1955
Indian J. Met. Geophysics 8, 93-98 (1957)
Poona, India
P. Jagannathan, O. Chacko & S. P. Venkiteshwaran

Measurements of total sun and sky radiation and of solar energy intensity in the different spectral regions were made at Poona ($18^{o}32'$N, $73^{o}51'$E) during an eclipse in which the sun was eclipsed to the maximum extent of 56 per cent.

An Eppley pyrheliometer was used to measure "the direct radiation from the Sun plus the diffuse radiation from the sky, on a unit area exposed horizontally," and an Angstrom pyrheliometer was used to measure "the energy distribution in various spectral regions." Measurements were taken on clear days prior to and after the eclipse to provide an average reference line. In the Angstrom pyrheliometer, the following filters were used: Blue (B. G. 8) (2. 8μ -1. 2μ and 0. 65μ -0. 35μ); Red (R. G. 5)(2. 8μ -0. 675μ); Red (R. G. 1)(2. 8μ -0. 6μ); Yellow (G. G. 5) (2. 8μ -0. 45μ).

The results are shown in Figures 43, 44, and 45. Figure 43 shows the solar radiation intensity in cal/cm^2 min vs IST - Indian Standard Time. Figure 44 shows the radiant energy in mw-hr/cm^2 vs IST plotted as a smooth curve. Figure 45 shows the intensity of solar radiation in the different spectral regions.

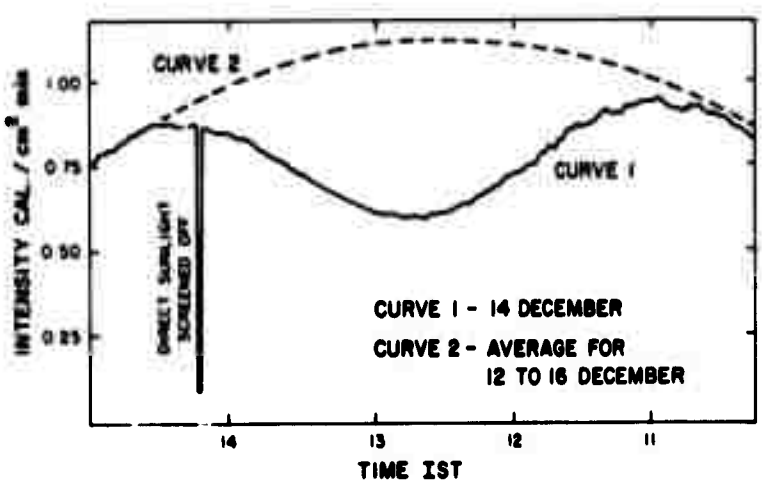

Figure 43. Total Solar Radiation on Horizontal Surface Recorded by Eppley Pyrheliometer at Poona During Solar Eclipse on 14 December 1955

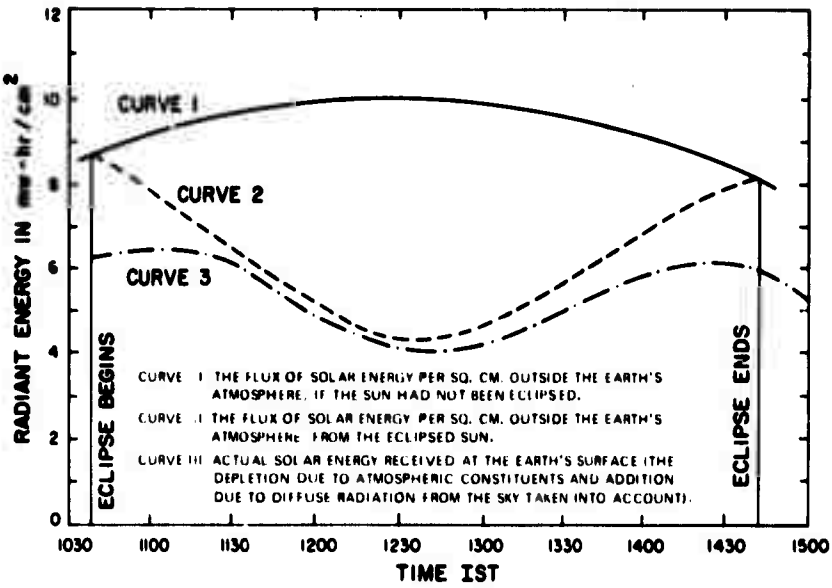

Figure 44. Solar Radiation at Poona on 14 December 1955 Plotted as a Smooth Curve Versus Time

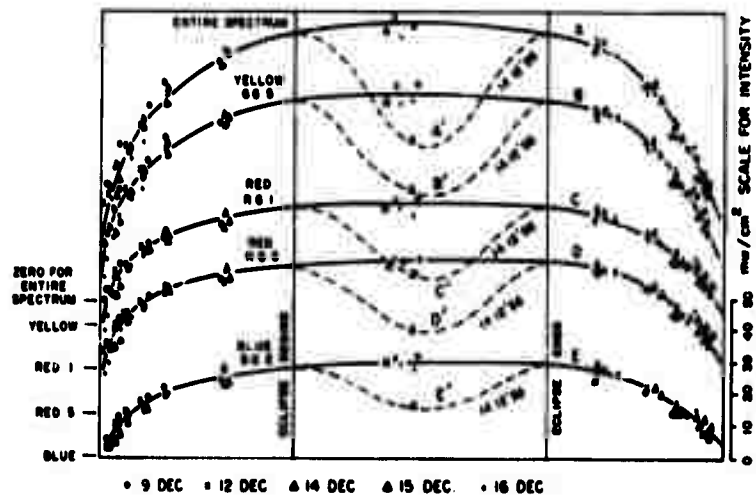

Figure 45. Intensity of the Solar Radiation in the Different Spectral Regions Recorded by Angstrom Pyrheliometer at Poona During Solar Eclipse on 14 December 1955

15 FEB 1961
Planet. Space Sci. 16, 647 (1968)
V. D. P. Sastri

During a partial solar eclipse with a maximum phase of 0.26, the total radiation from the sun and sky and the spectral distributions of skylight were measured "through a window from the second floor of the National Physical Laboratory, New Delhi, India."

An Eppley Pyroheliometer was used to record the total radiation from the sun and the sky. "The experimental setup and other details for the measurement of the spectral distribution were the same as those used by Das and Sastri.[31] The light measured was "about 60° from the sun at the beginning of the eclipse."

Figure 46 (A and B) shows "the eclipse curve along with the extrapolated curve, and the average curve for the two days preceding and the two days following the eclipse." "The percentage reduction in the total radiation from the sun and sky during the eclipse period was 11.84."

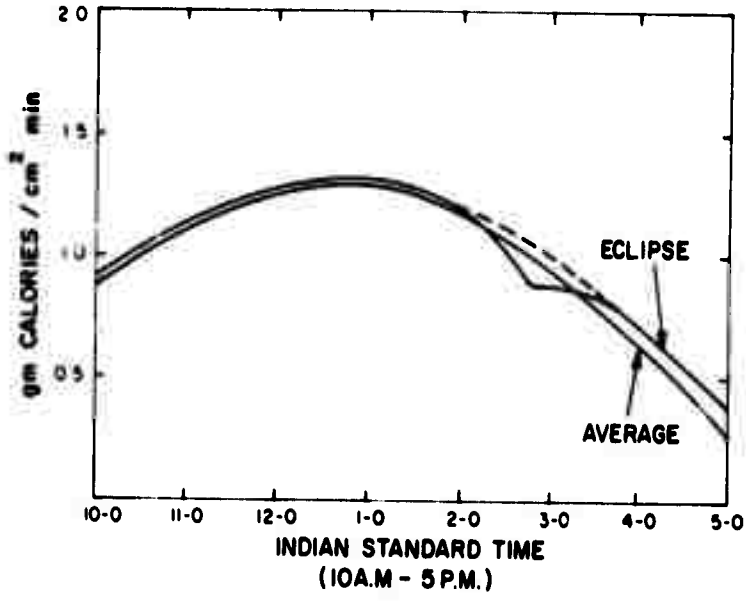

Figure 46. Total Radiation From Sun and Sky Recorded During the Partial Eclipse of 15 February 1961 Along With the Average of Total Radiation for Two Days Preceding and Two Days Following: A from 1000 to 1700 hr; and B from 1300 to 1545 hr

31. Das, S. R., and Sastri, V. D. P. (1965) J. Opt. Soc. Am. 55:319.

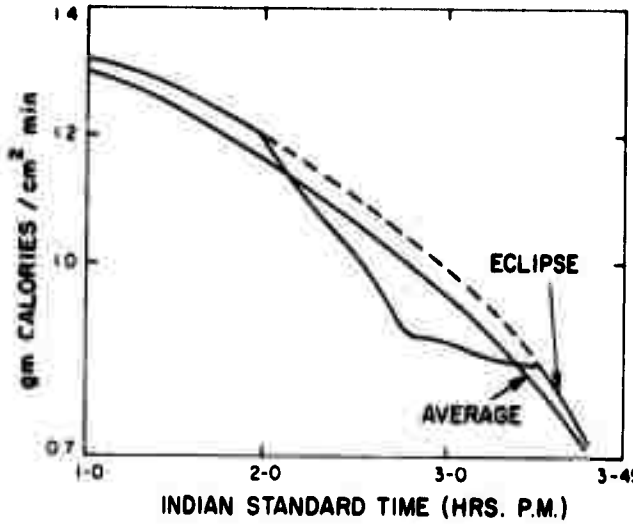

Figure 46 (Contd.). Total Radiation From Sun and Sky Recorded During the Partial Eclipse of 15 February 1961 Along With the Average of Total Radiation for Two Days Preceding and Two Days Following: A from 1000 to 1700 hr; and B from 1300 to 1545 hr

Part 5

Total Lunar Eclipses

12-13 APR 1968
From an unpublished paper by N. Rosenberg and D. J. Davis Jr.

During the total lunar eclipse, observations were made at Bedford, Massachusetts (42°28'N, 71°17'W) under excellent sky conditions with the lunar zenith angle ranging from 57°11' to 52°48' at midtotality to 64°57'. Zenith measurements were taken of the 5577 Å [OI] line and the continuum peaked at 5554 Å.

A two barrel interference filter photometer with each channel consisting of "a 10 cm diameter narrow band interference filter, a 25 cm objective lens, a 5° field stop in the focal plane of the objective lens, a light shutter, and a photomultiplier tube with a 23 mm cathode and an S-11 response," was used. The line filter peaked at 5577 Å had a half transmission band width of 12 Å, and the continuum filter peaked at 5554 Å had an 18 Å half transmission band width. Calibration was such that it was estimated "that our absolute values of line intensity are accurate to within 20 %."

Figure 47 shows the results plotted as Intensity in Rayleighs versus Time in E. S. T., with both curves related to a 12 Å band width.

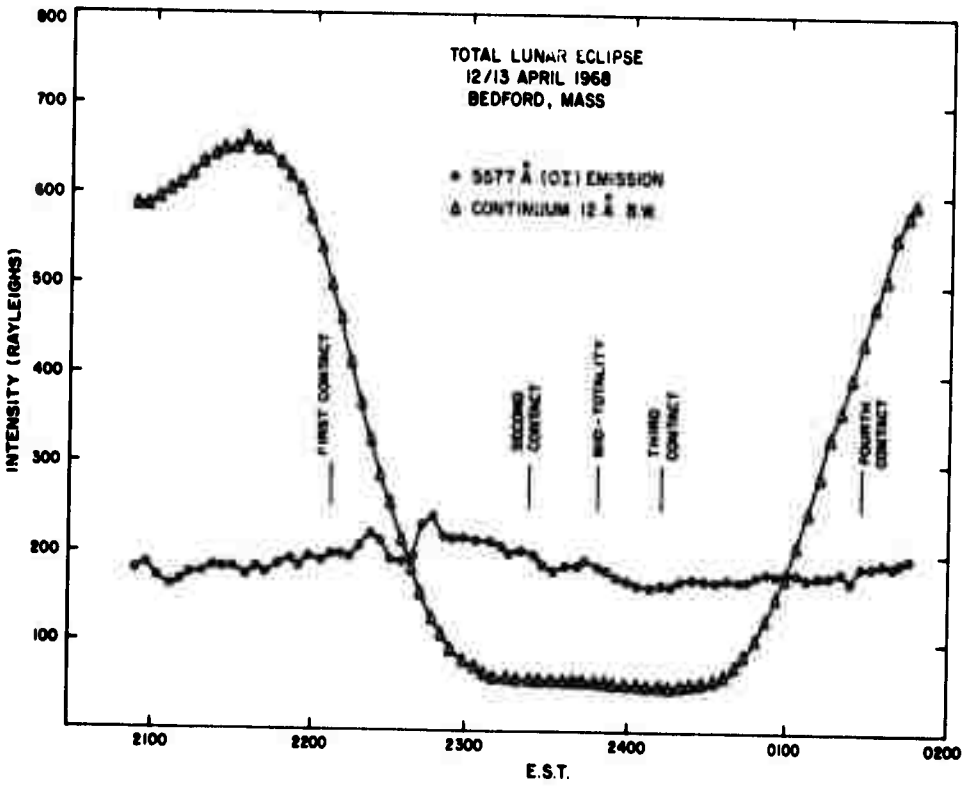

Figure 47. Intensity of the 5577 Å Line and the Continuum Peaked at 5554 Å During the Total Lunar Eclipse of 12 and 13 April 1968

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References

1. Sharp, W.E., Floyd, J.W.F., and Silverman, S.M. (1966) Zenith Skylight intensity and color during the total solar eclipse of 20 July 1963, Appl. Opt. 5:787-792.
2. Dandekar, B.S. (1968) Measurements of the zenith sky brightness and color during the total solar eclipse of 12 November 1966 at Quehau, Bolivia, Appl. Opt. 7:705-710.
3. Lloyd, J.W.F., and Silverman, S.M. (1971) Measurements of the zenith sky intensity and spectral distribution during the solar eclipse of 12 November 1966 at Bage, Brazil and on an aircraft, Appl. Opt. 10:1215-1219.
4. Velasquez, D.A. (1971) Zenith sky brightness and color change during the total solar eclipse of 12 November 1966 at Santa Ines, Peru, Appl. Opt. 10:1211-1214.
5. Dandekar, B.S., and Turtle, J.P. (1971) Daysky brightness and polarization during the total solar eclipse of 7 March 1971, Appl. Opt. 10:1220-1224.
6. Hall, W.N. (1971) Spectral changes in the zenith sky light during total solar eclipses, Appl. Opt. 10:1225-1231.
7. Sharp, W.E., Silverman, S.M., and Lloyd, J.W.F. (1971) A summary of sky brightness measurements during eclipses of the sun, Appl. Opt. 10:1207-1210.
8. Ranyard, A.C. (1879) Observations made during total eclipses, Mem. Roy. Astrophys. Soc. 41.
9. Ginzel, F.K. (1883, 1884) Astronomische Untersuchungen uber Finsternisse, Sitzber, Wien. Adak. Wiss, 88:629-755 (1883); 89:491-559 (1884).
10. Fotheringham, J.K. (1921, 1925) Historical Eclipses, Oxford: Clarendon Press, 1921; Visibility of stars in Great Britain during the solar eclipse of 24 January 1925, Monthly Notes Roy. Astrophys. Soc. 85:509-510.
11. Tousey, R., and Koomen, M.J. (1953) The visibility of stars and planets during twilight, J. Opt. Soc. Am. 43:177-183.

References

12. Hardy, A.C. (1967) How large is a point source? J. Opt. Soc. Am. 57:44-47.
13. Horman, M.H. (1967) Visibility of light sources against a background of uniform luminance, J. Opt. Soc. Am. 57:1516-1521.
14. Sky and Telescope (1970) 39:286-287.
15. Sky and Telescope (1966) 32:80-83.
16. Fisher, W.J. (1924) The brightness of lunar eclipses 1960-1922, Smithsonian Misc. Coll. 76(No. 9).
17. Link, F. (1956, 1969) Die Mondfinsternisse Liepzig: Akademische Verlagsgesellschaft, 1956; Eclipse Phenomena in Astronomy, New York: Springer-Verlag, 1969.
18. Abney, W. deW. and Festing (1887) Roy Soc. Proc. 43.
19. Smithsonian (1971) Misc. Coll. 66:7
20. Kunz, J., and Stebbins, J. (1919) Astrophys. J. 49:137.
21. King, E.S. (1926) Harvard College Circular No. 286.
22. Stetson, H.T., et al (1927) Astrophys. J. 66:65
23. Richardson, R.A., and Hulburt, E.O. (1949) J. Geophys. Res. 54:215.
24. The Airglow and the Aurorae (1955) Permagon Press, p. 355.
25. Ney et al (1960) Astrophys. J. 132:812.
26. Yesipov, V.F. (1960) Astronom. J. 37:1102.
27. Galperin, G.I., et al (1957) Mem. Soc. Roy. Sci. Liege 18:68.
28. Roach, F.E., and Pettit, H. (1960) J. Geophys. Res. 56:325.
29. Moore, J.G. (1964) ISA Transactions 3:301.
30. Ginzel, F.K. (346) Akadamie der Wisscenschaftern, Vienna: Matematisch - Naturwissenschaftliche Klasse. Sitzungsberichte. 88:629-755 and 89:491-559. Translated by Linguistic Systems, Inc., Cambridge, Mass.
31. Das, S.R., and Sastri, V.D.P. (1965) J. Opt. Soc. Am. 55:319.